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Scientific, Technical and Economic Committee for Fisheries (STECF) - Mediterranean assessments part 2 (STECF 16-08)

Edited by Massimiliano Cardinale, Giacomo Chato Osio and Finlay Scott

This report was reviewed by the STECF during its 51st plenary meeting held from 11 to 15 April 2016 in Brussels, Belgium

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Abstract

Commission Decision of 25 February 2016 setting up a Scientific, Technical and Economic Committee for Fisheries, C(2016) 1084, OJ C 74, 26.2.2016, p. 4–10. The Commission may consult the group on any matter relating to marine and fisheries biology, fishing gear technology, fisheries economics, fisheries governance, ecosystem effects of fisheries, aquaculture or similar disciplines. The Expert Working Group meeting of the Scientific, Technical and Economic Committee for Fisheries EWG 16-08 was held from 14 December to 18 December 2015 in Rome, Italy to assess the status of demersal and small pelagic stocks in the Mediterranean Sea against the proposed FMSY reference points. The report was reviewed by the STECF plenary in April 2016.

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SCIENTIFIC, TECHNICAL AND ECONOMIC COMMITTEE FOR FISHERIES (STECF)

Mediterranean assessments part 2 (STECF-15-16)

THIS REPORT WAS REVIEWED BY THE STECF DURING ITS 51st PLENARY MEETING HELD FROM 11 TO 15 APRIL 2016 IN BRUSSELS, BELGIUM

Request to the STECF

STECF is requested to review the report of the STECF Expert Working Group meeting, evaluate the findings and make any appropriate comments and recommendations.

Observations of the STECF

The meeting was held in Rome, Italy, from 14th to 18th of December 2015 and hosted by National Research Council of Italy (CNR). It was the second of the STECF expert meetings, within STECF's 2015 work programme, planned to undertake stock assessments in the Mediterranean Sea. The meeting was chaired by Massimiliano Cardinale and attended by 21 experts, including 4 STECF members. Furthermore, two JRC experts, one observer and one DG MARE representative were also present. Data of historical fisheries and scientific surveys derived from the official Mediterranean DCF data call issued to Member States on April 2015 with deadline on 2nd of July 2015 and 'operational deadline' on 17th of August.

The terms of reference for EWG-15-11of the meeting were:

ToR 1 – Compile and provide the most updated information on stock identification, age and growth, maturity, feeding, habitat, and natural mortality.

Table 1.1.1 – List of proposed stocks

Geographical Sub-Areas	Common name	Scientific name
GSA 17-18	Hake	*Merluccius merluccius*
GSA 19	Hake	*Merluccius merluccius*
GSA 17-18	Red mullet	*Mullus barbatus*
GSA 19	Red mullet	*Mullus barbatus*
GSA 17	Common sole	*Solea solea*
GSA 17-18	Norway lobster	*Nephrops norvegicus*
GSA 17	Spot-tail mantis shrimp	*Squilla mantis*
GSA 18	Spot-tail mantis shrimp	*Squilla mantis*
GSA 17-18	Spot-tail mantis shrimp	*Squilla mantis*
GSA 18	Deep-water rose shrimp	*Parapenaeus longirostris*
GSA 19	Deep-water rose shrimp	*Parapenaeus longirostris*
GSA 17-18-19	Deep-water rose shrimp	*Parapenaeus longirostris*
GSA 18	Giant red shrimp	*Aristaeomorpha foliacea*
GSA 19	Giant red shrimp	*Aristaeomorpha foliacea*
GSA 18-19	Giant red shrimp	*Aristaeomorpha foliacea*

In case it is not possible to carry out an evaluation of those stocks listed in table 1.1.1, below is provided a reserve list of stocks (Table 1.1.2.).

Table 1.1.2. – Reserve stock list

Geographical	Common name	Scientific name

Sub-Areas		
GSA 25	Red mullet	*Mullus barbatus*
GSA 25	Striped red mullet	*Mullus surmuletus*
GSA 15-16	Giant red shrimp	*Aristaeomorpha foliacea*
GSA 15-16	Norway lobster	*Nephrops norvegicus*
GSA 22-23	Hake	*Merluccius merluccius*
GSA 22-23	Red mullet	*Mullus barbatus*
GSA 22-23	Norway lobster	*Nephrops norvegicus*

ToR 2 – Compile and provide complete sets of annual data on landings and discards for the longest time series available up to and including 2014. This should be presented by fishing gear as well as by size/age structure.

ToR 3 – Compile and provide complete sets of annual data on fishing effort for the longest time series available up to and including 2014. This should be described in terms of amount of vessels, time (days at sea, soaking time, or other relevant parameter) and fishing power (gear size, boat size, horse power, etc.) by Member State and fishing gear. Data shall be the most detailed possible to support the establishment of a fishing effort or capacity baseline.

ToR 4 – Compile and provide indices of abundances and biomass by year and size/age structure for the longest time series available up to and including 2014.

ToR 5 – Assess trends in historic and recent stock parameters on fishing mortality, stock biomass, spawning stock biomass, and recruitment. Different assessment models should be applied as appropriate, including retrospective analyses. The selection of the most reliable assessment should be explained. Assumptions and uncertainties should be specified.

ToR 6 - Propose and evaluate candidate MSY value, range of values and safeguard points in terms of fishing mortality and stock biomass. The proposed values shall be related to long-term high yields and low risk of stock/fishery collapse and ensure that the exploitation levels restore and maintain marine biological resources at least at levels which can produce the maximum sustainable yield.

ToR 7 - Provide short and medium term forecasts of spawning stock biomass, stock biomass and catches. The forecasts shall include different management scenarios, inter alia: zero catch, the status quo fishing mortality, and target to FMSY or other appropriate proxy by 2018 and 2020. In particular, predict the level of fishing effort exerted by the different fleets which is commensurate with the short- and medium-term forecasts of the proposed scenarios.

ToR 8 - Summarize and concisely describe all data quality deficiencies, including possible limitations with the surveys of relevance for stock assessments and fisheries. Such review and description are to be based on the data format of the official DCF data call for the Mediterranean Sea launched on the 22 April 2015. Identify further research studies and data collections which would be required for improved fish stock assessments. This review shall be presented in a manner that is compatible with the online platform developed by the JRC for data issues[2].

ToR 9 - Provide a synoptic overview of: (i) the fishery; (ii) the most recent state of the stock (spawning stock biomass, stock biomass, recruits, and exploitation level by fishing gear); (iii) the source of data and methods and; (iv) the management advice, including MSY value, range of values and safeguard points.

ToR 10 - Review the assessments of sardine and anchovy in the Adriatic Sea (GSAs 17-18), made by the GFCM-SAC at the Working Group on stock assessment on small pelagic species (23-27 November 2015).

ToR 11 - Review the scientific basis of the Spanish management plan "rastrillo de cadenas" and its sampling programme. Make any appropriate comments and recommendations, with respect to the measures proposed therein.

STECF comments

STECF observes that EWG 15-16 undertook the stock assessment of 15 stocks.
Mediterranean hake and red mullet were assessed in GFCM GSA 19 and jointly for GFCM GSAs 17 and 18. Common sole was assessed in GFCM GSA 17. Norway lobster was assessed jointly in GFCM GSAs 17 and 18. Spot-tail mantis shrimp was assessed in GFCM GSAs 17 and 18 and jointly for GFCM GSAs 17 and 18. Deep-water rose shrimp was assessed in GFCM GSAs 18 and 19 and jointly for GFCM GSAs 17, 18 and 19. Giant red shrimp was assessed in the individual GFCM GSAs 18 and 19 and jointly for GFCM GSAs 18 and 19.

For two stocks (Norway lobster in GSAs 17-18 and Giant red shrimp in GSA 18), the assessment was conducted, but not accepted due data issues. In particular for Norway lobster in GSAs 17-18, no consensus was reached during EWG 15-16 about the stock configuration to be analysed (jointly GSA 17-18 or separately for Pomo/Jabuka pit in GSA 17, outside the Pomo/Jabuka pit in GSA17 and GSA 18). If a future assessment is required to be carried out, several potential methods are available to do so.

STECF notes that the 13 stocks for which assessment was accepted were classified as exploited above F_{MSY} (see Table 1.1.3 for details).

Table 1.1.3 - Synoptic table of the stock assessed during EWG 15-11. In red are stocks for which current F is larger than F_{MSY}.

Stock area	Common name	Species	Assessment	F*	F_{MSY}	F_{MSY} range	F/F_{MSY}	B_{lim}	B_{curr}	B/B_{lim}	Short term	MSE
GSA 17-18	Hake	*Merluccius merluccius*	XSA	0.89	0.16	0.11 - 0.23	5.56	2569	3285	1.28	Yes	0
GSA 19	Hake	*Merluccius merluccius*	XSA	0.87	0.18	0.12 - 0.25	4.83	452	1167	2.58	Yes	0
GSA 17-18	Red mullet	*Mullus barbatus*	XSA	0.54	0.41	0.27 - 0.56	1.32	3439	6635	1.93	Yes	
GSA 19	Red mullet	*Mullus barbatus*	XSA	0.99	0.45	0.30 - 0.62	2.20	496	496	1.00	Yes	0
GSA 17	Common sole	*Solea solea*	SS3, XSA	0.62	0.26	0.18 - 0.36	2.38	1454	3545	2.44	Yes	
GSA 17-18	Norway lobster	*Nephrops norvegicus*	XSA	not accepted								
GSA 17	Spot-tail mantis shrimp	*Squilla mantis*	XSA	0.63	0.48	0.32 - 0.66	1.31	10452	11536	1.10	Yes	
GSA 18	Spot-tail mantis shrimp	*Squilla mantis*	XSA	1.05	0.43	0.29 - 0.59	2.44	848	1712	2.02	Yes	0
GSA 17-18	Spot-tail mantis shrimp	*Squilla mantis*	XSA	0.69	0.56	0.37 - 0.76	1.23	12878	13176	1.02	Yes	
GSA 18	Deep-water rose shrimp	*Parapenaeus longirostris*	XSA	1.46	0.72	0.48 - 0.98	2.03	1580	1963	1.24	Yes	0
GSA 19	Deep-water rose shrimp	*Parapenaeus longirostris*	XSA	1.45	0.89	0.59 - 1.21	1.63	386	386	1.00	Yes	
GSA 17-18-19	Deep-water rose shrimp	*Parapenaeus longirostris*	XSA	1.53	0.69	0.46 - 0.94	2.22	2863	3557	1.24	Yes	0
GSA 18	Giant red shrimp	*Aristaeomorpha foliacea*	XSA	not accepted								
GSA 19	Giant red shrimp	*Aristaeomorpha foliacea*	XSA	0.66	0.29	0.19 - 0.40	2.28	44	250	5.68	Yes	0
GSA 18-19	Giant red shrimp	*Aristaeomorpha foliacea*	XSA, a4a	0.46	0.42	0.28 - 0.57	1.10	184	525	2.85	Yes	0

*Last year

STECF notes that EWG 15-16, in fulfilment of Tor 9, estimated F_{MSY} values and ranges, and safeguard points in terms of stock biomass. EWG 15-16 addressed this TOR by using Management Strategy Evaluation (MSE) to evaluate whether the FMSY upper range is precautionary or not. The MSE functions were run using R-scripts developed for and tested during STECF 15-09. The MSE included stochasticity in: a) variability of the recruitment around the geometric mean of the last 3 years of data, b) uncertainty in the MEDITS survey indices to represent the true density (observation error), and c) uncertainty in the perceived stock status to represent the true abundance (assessment error).

F_{MSY} ranges were proposed and tested for robustness of the upper range (F_{upper}) for all assessed stocks. F_{upper} was considered safe if the probability of SSB to fall below B_{lim} at F = F_{upper} was less than 5%, which was the case for all stocks for which the results of the MSE were considered valid. F_{MSY} ranges are summarized in Table 4.1-3.

STECF notes that EWG 15-16 conducted short term forecasts of stock size and catches for 13 stocks. The forecasts were also conducted by fleet. No medium term forecasts were carried out for any of the stocks assessed at the meeting because no meaningful stock-recruitment relationship was estimated for any of the stock assessed.

STECF notes that in fulfilment of TOR (8), stock specific evaluations of the data quality were conducted for all stocks requested under ToR (1-7) by the experts.

STECF notes that some unresolved issues remain, in particular relating to data quality for certain stocks and delays in data submission. Moreover, the change in the timing of MEDITS survey has occurred in recent years. According to the MEDITS manual V 7 2013, the period of the MEDITS survey is centred in June (from May to July). This is a fundamental aspect of a standardized international survey that is used to perform stock assessment and provide management advice. The timing has likely a significant effect on the CPUE and the size composition of fish sampled by the survey. Shifts in survey timing could impact its internal consistency, and thus cohorts are more difficult to track in time. This can result in poorly fitting stock assessments and poor estimates of stock status.

STECF notes that EWG 15-16, in fulfilment of TOR (10), was requested to review the assessments of sardine and anchovy in the Adriatic Sea (GSAs 17-18), made by the GFCM-SAC at the Working Group on stock assessment on small pelagic species (23-27 November 2015). Given that the input data for both stocks of anchovy and sardine were substantially revised in different key aspects and were not available during the meeting, EWG 15-16 was not able to conduct the review of the assessments of sardine and anchovy in the Adriatic Sea (GSAs 17-18).

STECF notes that EWG 15-16, in fulfilment of TOR (11), was requested to review the scientific basis of the Spanish management plan "*rastrillo de cadenas*" and its sampling programme. The EWG 15-16 concluded that the information in the MP is not sufficient for assessing the sustainability of the activity neither from a biological nor from a socio-economic point of view.

STECF conclusions

STECF concludes that the EWG-15-16 adequately addressed most of the Terms of Reference, except ToR 10.

STECF concludes that the stock assessment results presented in the EWG 15-16 report and summarised in Table 5.1-3 above represent the best information currently available on the status and exploitation rate on those stocks.

For three species, spot-tail mantis shrimp, deep water rose shrimp, giant red shrimp, accepted assessments were undertaken for single GSA and for GSAs combined (respectively 17-18, 17-18-19, 18-19). The EWG 15-16 did not indicate which assessments are likely to best reflect the status of these species in the Adriatic and western Ionian Sea.

STECF concludes that according to StockMed project (Fiorentino et al., 2015), for deep water rose shrimp and giant red shrimp the combined assessments are likely to better reflect the status of these stocks.

STECF is unable to determine the best assessment configuration for spot-tail mantis shrimp, as the stock identity is still unclear for this species in the area.

In relation to the assessment of Norway lobster in GSAs 17 and 18, STECF concludes that the assessment should be done using methods that allow the separation of the stock into different sub-populations (i.e. Pomo/Jabuka pit; GSA 17 outside the Pomo/Jabuka pit; GSA 18).

STECF is unable to determine if changes in the timing of MEDITS survey that occurred in the last years has an impact in the assessments carried out during EWG 15-16 and EWG 15-11. Such an analysis should be conducted.

STECF concludes that regarding ToR 10 (review of the assessments of sardine and anchovy in the Adriatic Sea made by the GFCM-SAC), a better coordination among GFCM-SAC, FAO AdriaMed regional project and EU is needed in order to make best use of the human resources and provide advice for a sustainable management of small pelagics stocks in the Adriatic Sea (see also items 6.8 and 7.5 in PLEN report).

Reference

Fiorentino F., E. Massutì, F. Tinti, S. Somarakis, G. Garofalo, T. Russo, M.T. Facchini, P.Carbonara, K. Kapiris, P. Tugores, R. Cannas, C. Tsigenopoulos, B. Patti, F. Colloca, M. Sbrana, R. Mifsud, V. Valavanis, and M.T. Spedicato, 2014. Stock units: Identification of distinct biological units (stock units) for different fish and shellfish species and among different GFCM-GSA. STOCKMED Deliverable 03: FINAL REPORT. September 2014, 215 p.

Report to the STECF

EXPERT WORKING GROUP ON Mediterranean assessments part 2 (EWG-15-16)

Rome, Italy, 14-18 December 2015

1. Executive summary

The meeting was the second of two STECF expert meetings, within STECF's 2015 working schedule, planned to undertake stock assessments of demersal/small pelagic species in the Mediterranean Sea. The meeting was organized by Italian CNR in Rome from 14st of December to 18th of December 2015 and was kindly hosted by the Italian CNR. The meeting was chaired by Massimiliano Cardinale and attended by 21 experts in total, including 4 STECF members. Furthermore, two JRC experts and one DG MARE representative were present (see Chapter 10).

Historical fisheries and scientific survey data were obtained from the official Mediterranean DCF data call issued to Member States on April 2015 with deadline on 2nd of July 2015 and 'operational deadline' on 17th of August.

In fulfilment of **TORs 1-7** the EWG 15-16 undertook the stock assessment of 15 stocks, which are listed in Table 1. For 2 stocks (Norway lobster in GSA 17-18 and Giant red shrimp in GSA 18), the assessment was conducted but not accepted due to data issues, while a total of 13 out of 13 stocks with an accepted assessment were classified as exploited unsustainably (see Table 1 for details). For Norway lobster in GSA 17-18 no consensus was reached during EWG 15-16, although the majority of the participants were of the opinion that the assessment should not be accepted due to data issues.

Table 1 . Synoptic table of the stock assessed during EWG 15-16. In red are stocks for which current F is larger than F_{MSY}. MSE indicates the probability of the stock to fall below B_{lim} fishing at the upper limit of F in the long term. Missing value in the MSE column indicates that the MSE was conducted but was not considered valid.

Stock area	Common name	Species	Assessment	F*	F_{MSY}	F_{MSY} range	F/F_{MSY}	B_{lim}	B_{curr}	B/B_{lim}	Short term	MSE
GSA 17-18	Hake	*Merluccius merluccius*	XSA	0.89	0.16	0.11 - 0.23	5.56	2569	3285	1.28	Yes	0
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*Last year

EWG 15-16 was requested to propose and evaluate candidate MSY values and ranges, and safeguard points in terms of stock biomass. EWG 15-16 addressed this TOR by using Management Strategy Evaluation (MSE) to evaluate if the MSY ranges are precautionary or not. The MSE functions were run using R scripts developed for and tested during STECF 15-09. The MSE included uncertainty in: a) recruitment around a mean level resulting from the geometric mean of the last 3 years of data, b) uncertainty in the MEDITS tuning fleet indices, and c) uncertainty in the perceived stock status.
F_{msy} ranges were proposed and tested for robustness of the higher F (F_{upper}) for all assessed stocks. F_{upper} was considered safe if the probability of SSB to fall below B_{lim} at F = F_{upper} was equal to 0, which

was the case for all stocks for which the MSE was considered valid. F_{MSY} ranges are summarized in Table 1.

EWG 15-16 also conducted short term forecasts of stock size and catches for 13 stocks. The forecasts were also produced by fleet. No medium term forecasts were carried out for any of the stocks assessed at the meeting because no meaningful stock-recruitment relationship was estimated for any of the stock assessed. However the MSE where F_{upper} would be reached in 2020 is a long term forecast under the assumption of mean recruitment which is effectively a conservative projection of stock trends at the upper range of F_{MSY}.

The data call for EWG 15-16 was issued on April 2015. The 'legal' deadline for submissions was the 2nd of July 2015. Upon communication with the member states some data tables were corrected and re-uploaded in relation to the 'operational' deadline of the 17th August 2015. Data was uploaded by each country according to the following table:

Timeline of data upload, by data type, from Mediterranean Member States, data call deadline of the 2nd of July 2015..

	CYP	ESP	FRA	GRC	HRV	ITA	MLT	SVN
A_CATCH	02/07/15	01/07/15	02/07/15	**11/08/15**	01/07/15	30/06/15	02/07/15	05/06/15
B_LANDINGS	01/07/15	01/07/15	02/07/15	**02/08/15**	01/07/15	30/06/15	02/07/15	05/06/15
C_DISCARDS	01/07/15	**04/08/15**	02/07/15	**14/08/15**	01/07/15	01/07/15	02/07/15	05/06/15
D_EFFORT	02/07/15	01/07/15	02/07/15	02/07/15	02/07/15	30/06/15	02/07/15	05/06/15
ML	**03/07/15**	01/07/15	02/07/15	**03/07/15**	01/07/15	01/07/15	02/07/15	05/06/15
MA	**03/07/15**	01/07/15	02/07/15	**13/07/15**	01/07/15	01/07/15	02/07/15	05/06/15
GP	02/07/15	01/07/15	02/07/15	**17/08/15**	01/07/15	01/07/15	02/07/15	**No Data Submitted**
SRL	02/07/15	01/07/15	02/07/15	**03/07/15**	01/07/15	01/07/15	02/07/15	05/06/15
SRA	02/07/15	01/07/15	02/07/15	**13/07/15**	01/07/15	01/07/15	02/07/15	05/06/15
MEDITS_TA	**No Data Submitted**	01/07/15	19/06/15	02/07/15	**31/07/15**	30/06/15	02/07/15	05/06/15
MEDITS_TB	**No Data Submitted**	01/07/15	19/06/15	**11/07/15**	**31/07/15**	30/06/15	02/07/15	05/06/15
MEDITS_TC	**No Data Submitted**	01/07/15	19/06/15	**11/07/15**	**31/07/15**	30/06/15	02/07/15	05/06/15
MEDITS_TE	**No Data Submitted**	01/07/15	19/06/15		**31/07/15**	30/06/15	02/07/15	05/06/15
ABUND	**No Data Submitted**	01/07/15	19/06/15	**14/08/15**	02/07/15	30/06/15	02/07/15	**No Data Submitted**
BIOMASS	**No Data Submitted**	01/07/15	19/06/15	**14/08/15**	02/07/15	30/06/15	02/07/15	**No Data Submitted**
ABUND_BIOM	**No Data Submitted**	01/07/15	19/06/15	**15/08/15**	02/07/15	30/06/15	02/07/15	**No Data Submitted**

The overall 2015 Data Call performance of data coverage, timeliness and progress of submissions by member state and main table/variable is available on the dedicated weblink: http://datacollection.jrc.ec.europa.eu/coverage

In fulfilment of TOR (8), stock specific evaluations of the data quality were conducted for all stocks requested under TOR (1-7) by the EWG 15-16 experts. Moreover, JRC Data Collection team examined the data coverage and quality of the fisheries and survey data. Results of the evaluations are reported under Chapter 8 and in details at the end of the assessment section of each stock.

In fulfilment of TOR (8), stock specific evaluations of the data quality were conducted for all stocks requested under TOR (1-7) by the EWG 15-16 experts. Moreover, JRC team examined the data coverage and quality of the fisheries and survey data. Results of the evaluations are reported under Chapter 8 and in details at the end of the assessment section of each stock.

In fulfilment of TOR (9), a synoptic table was provided by EWG 11-16 (see Table 1).

In fulfilment of TOR (10), EWG 11-16 was requested to review the assessments of sardine and anchovy in the Adriatic Sea (GSAs 17-18), made by the GFCM-SAC at the Working Group on stock assessment on small pelagic species (23-27 November 2015). Given that the input data for both stocks of anchovy and sardine were substantially revised in different key aspects as described above, EWG 15-16 considers that to perform a review of the assessments, a platform should be established where the same data are available across working groups (STECF, GFCM, AdriaMed). EWG 15-16 consider that the minimum level at which the review should be performed should be in line with the level 2 as defined by EWG 15-16 (see chapter 8 for details). As this condition was not fulfilled at the meeting, EWG 15-16 was not able to conduct the review of the assessments of sardine and anchovy in the Adriatic Sea (GSAs 17-18). EWG 15-16 hopes that due steps are taken across institutions involved to ensure that in the future the conditions will be met for the STECF EWG to review stock assessments made by GFCM and vice versa.

In fulfilment of TOR (11), EWG 15-16 was requested to review the scientific basis of the Spanish management plan "rastrillo de cadenas" and its sampling programme. The EWG 15-16 concludes that the information included in the MP is not sufficient for assessing the sustainability of the activity neither under biological nor socio-economic points of view (see Chapter 7 for details).

2. Findings And Conclusions Of The Working Group

Stock-Specific Findings & Conclusions

See the stock specific summary sheets.

3. Follow Up Items

None

4. Introduction

The expert working group on Mediterranean stock and fisheries assessment held its second meeting planned for 2015 in Rome (Italy), 14-18 December 2015.

The Chairman opened the meeting at 09:00 on Monday, 14 December 2015, and adjourned the meeting by 16:00 on Friday, 18 December 2015. The meeting was attended by 21 experts in total, including 4 STECF members and 2 JRC experts.

The structure of the present report is in accordance with the terms of reference to STECF, as defined in the following chapter.

4.1 Terms Of Reference For Ewg-15-16

For the 15 stocks given in Table 4.1.1, the STECF-EWG 15-16 is requested to:

ToR 1 – Compile and provide the most updated information on stock identification, age and growth, maturity, feeding, habitat, and natural mortality.

Table 4.1.1 – List of proposed stocks

Geographical Sub-Areas	Common name	Scientific name
GSA 17-18	Hake	*Merluccius merluccius*
GSA 19	Hake	*Merluccius merluccius*
GSA 17-18	Red mullet	*Mullus barbatus*
GSA 19	Red mullet	*Mullus barbatus*
GSA 17	Common sole	*Solea solea*
GSA 17-18	Norway lobster	*Nephrops norvegicus*
GSA 17	Spot-tail mantis shrimp	*Squilla mantis*
GSA 18	Spot-tail mantis shrimp	*Squilla mantis*
GSA 17-18	Spot-tail mantis shrimp	*Squilla mantis*
GSA 18	Deep-water rose shrimp	*Parapenaeus longirostris*
GSA 19	Deep-water rose shrimp	*Parapenaeus longirostris*
GSA 17-18-19	Deep-water rose shrimp	*Parapenaeus longirostris*
GSA 18	Giant red shrimp	*Aristaeomorpha foliacea*
GSA 19	Giant red shrimp	*Aristaeomorpha foliacea*
GSA 18-19	Giant red shrimp	*Aristaeomorpha foliacea*

In case it is not possible to carry out an evaluation of those stocks listed in table 4.1.1, below is provided a reserve list of stocks (Table 4.1.2.).

Table 4.1.2. – Reserve stock list

Geographical Sub-Areas	Common name	Scientific name
GSA 25	Red mullet	*Mullus barbatus*
GSA 25	Striped red mullet	*Mullus surmuletus*
GSA 15-16	Giant red shrimp	*Aristaeomorpha foliacea*
GSA 15-16	Norway lobster	*Nephrops norvegicus*
GSA 22-23	Hake	*Merluccius merluccius*
GSA 22-23	Red mullet	*Mullus barbatus*
GSA 22-23	Norway lobster	*Nephrops norvegicus*

ToR 2 – Compile and provide complete sets of annual data on landings and discards for the longest time series available up to and including 2014. This should be presented by fishing gear as well as by size/age structure (see Annex II for more details).

ToR 3 – Compile and provide complete sets of annual data on fishing effort for the longest time series available up to and including 2014. This should be described in terms of amount of vessels, time (days at sea, soaking time, or other relevant parameter) and fishing power (gear size, boat size, horse power, etc.) by Member State and fishing gear. Data shall be the most detailed possible to support the establishment of a fishing effort or capacity baseline (see Annex II for more details).

ToR 4 – Compile and provide indices of abundances and biomass by year and size/age structure for the longest time series available up to and including 2014 (see Annex II for more details).

ToR 5 – Assess trends in historic and recent stock parameters on fishing mortality, stock biomass, spawning stock biomass, and recruitment. Different assessment models should be applied as appropriate, including retrospective analyses. The selection of the most reliable assessment should be explained. Assumptions and uncertainties should be specified.

ToR 6 - Propose and evaluate candidate MSY value, range of values and safeguard points in terms of fishing mortality and stock biomass. The proposed values shall be related to long-term high yields and low risk of stock/fishery collapse and ensure that the exploitation levels restore and maintain marine biological resources at least at levels which can produce the maximum sustainable yield.

ToR 7 - Provide short and medium term forecasts of spawning stock biomass, stock biomass and catches. The forecasts shall include different management scenarios, inter alia: zero catch, the status quo fishing mortality, and target to F_{MSY} or other appropriate proxy by 2018 and 2020. In particular, predict the level of fishing effort exerted by the different fleets which is commensurate with the short- and medium-term forecasts of the proposed scenarios.

ToR 8 - Summarize and concisely describe all data quality deficiencies, including possible limitations with the surveys of relevance for stock assessments and fisheries. Such review and description are to be based on the data format of the official DCF data call for the Mediterranean Sea launched on the 22 April 2015. Identify further research studies and data collections which would be required for improved fish stock assessments. This review shall be presented in a manner that is compatible with the online platform developed by the JRC for data issues[2].

ToR 9 - Provide a synoptic overview of: (i) the fishery; (ii) the most recent state of the stock (spawning stock biomass, stock biomass, recruits, and exploitation level by fishing gear); (iii) the source of data and methods and; (iv) the management advice, including MSY value, range of values and safeguard points.

ToR 10 - Review the assessments of sardine and anchovy in the Adriatic Sea (GSAs 17-18), made by the GFCM-SAC at the Working Group on stock assessment on small pelagic species (23-27 November 2015).

ToR 11 - Review the scientific basis of the Spanish management plan "rastrillo de cadenas" and its sampling programme. Make any appropriate comments and recommendations, with respect to the measures proposed therein. Particularly, advice whether the management plan addresses the elements listed in Annex III.

[1] Medium term forecast only when an acceptable stock-recruitment relationship is identifiable.

[2] Castro Ribeiro C. (2015) Fisheries Data Collection Framework - The DCF Reporting and Implementation Cycles and the Data End-user Feedback, JRC Technical report.

[3] We have been informed that, due to time constraint and translation period, the management plan and the sampling programme will be available on the 4 December 2015.

ANNEX I

Table I – List of suggested stocks to be assessed by the STECF-EWG 15-16.

Geographical Sub-Areas	Common name	Scientific name
GSA 17-18	Hake	*Merluccius merluccius*
GSA 19	Hake	*Merluccius merluccius*
GSA 17-18	Red mullet	*Mullus barbatus*
GSA 19	Red mullet	*Mullus barbatus*
GSA 17	Common sole	*Solea solea*
GSA 17-18	Norway lobster	*Nephrops norvegicus*
GSA 17	Spot-tail mantis shrimp	*Squilla mantis*
GSA 18	Spot-tail mantis shrimp	*Squilla mantis*
GSA 17-18	Spot-tail mantis shrimp	*Squilla mantis*
GSA 18	Deep-water rose shrimp	*Parapenaeus longirostris*
GSA 19	Deep-water rose shrimp	*Parapenaeus longirostris*
GSA 17-18-19	Deep-water rose shrimp	*Parapenaeus longirostris*
GSA 18	Giant red shrimp	*Aristaeomorpha foliacea*

GSA 19	Giant red shrimp	*Aristaeomorpha foliacea*
GSA 18-19	Giant red shrimp	*Aristaeomorpha foliacea*

Table II – Reserve list of stocks. To be used in case it is not possible to carry out an evaluation of those stocks listed in Table I.

Geographical Sub-Areas	Common name	Scientific name
GSA 25	Red mullet	*Mullus barbatus*
GSA 25	Striped red mullet	*Mullus surmuletus*
GSA 15-16	Giant red shrimp	*Aristaeomorpha foliacea*
GSA 15-16	Norway lobster	*Nephrops norvegicus*
GSA 22-23	Hake	*Merluccius merluccius*
GSA 22-23	Red mullet	*Mullus barbatus*
GSA 22-23	Norway lobster	*Nephrops norvegicus*

The joint assessments have been proposed on the basis of STOCKMED and management needs. However, these suggestions can be modified according to experts' knowledge and to the most recent scientific information.

ANNEX II

Guidance for the preparation of the final report (specific sections 1.5 – 1.7)

SECTION 1.5	**FISHERIES**	**<u>Landings</u>** Total landings/year * Landings/fishing gear/year * Landings /fishing gear/year/size structure Landings /fishing gear/year/age structure **<u>Discards</u>** Total discards/year * Discards/fishing gear/year * Discards/fishing gear/year/size structure Discards/fishing gear/year/age structure **<u>Fishing effort</u>** Fishing effort (GT*days at sea)/year * Fishing effort (GT*days at sea)/fishing gear/year * Fishing effort (Days at sea)/year * Fishing effort (Days at sea)/fishing gear/year *
SECTION 1.6	**SCIENTIFIC SURVEYS**	Abundance index/year Abundance index/year/size structure Abundance index/year/age structure

		Biomass index/year Biomass index/year/size structure Biomass index/year/age structure
SECTION 1.7	**STOCK ASSESSMENT**	**<u>Results</u>** * Fishing mortality Fishing mortality/fishing gear Recruitment SSB TB **<u>Reference points</u>** * F_{MSY}, F_{upper} and F_{lower} B_{MSY}, B_{lim}, B_{pa} **<u>Predictions</u>** * *For the different scenarios,* Fishing mortality Fishing mortality/fishing gear Catches Catches/fishing gear Fishing effort/fishing gear SSB

* *Please, provide these variables at least in numerical values (not only figures).*

ANNEX III

The STECF is request to advice whether the management plan addresses: (a) the description and classification of the fishing gear rastrillo de cadenas; (b) the characterisation of the fishery, including the fishing grounds, target and non-target species, fleet composition, fishing effort, total catches (landings and discards) and CPUE; (c) size structure of the target and accompanying species (both landings and discards); (d) conservation objectives and; (e) technical and conservation measures that are consistent with the precautionary approach to fisheries management.

Particularly, advice whether the scientific monitoring plan (Appendix III) foresees the collection of the relevant information to estimate: (i) the status of the exploited resources, including quantifiable targets; (ii) the conservation reference points; (iii) the level of unwanted catches that are below the MCRS[1]; (iv) the socio-economic performance of the fishery; and (v) the impacts of the fishing activity on the marine ecosystem and estimation of survival rate of discarded individuals. Since the information to be collected is intended to complement the current management plan, the STECF should have a special focus on this point.

1 Minimum Conservation Reference Size (MCRS)

5 ASSESS TRENDS IN HISTORIC AND RECENT STOCK PARAMETERS

5.1 SUMMARY SHEETS

5.1.1 SUMMARY SHEET OF HAKE IN GSA 17-18

Species common name: European Hake
Species scientific name: *Merluccius merluccius*
Geographical Sub-area(s) GSA(s): 17-18

Stock development over time

SSB shows a fluctuating trend, with the higher value estimated in 2009, 3635 tonnes, and the lower value in 2012, 2569 tonnes. Recruitment shows a slightely decreasing trend, the higher value has been estimated in 2008, whereas the lower value in 2013. Fishing mortality decreases over time from a maximum value of 1.48 in 2008 to the minimum value of 0.89 in 2014.

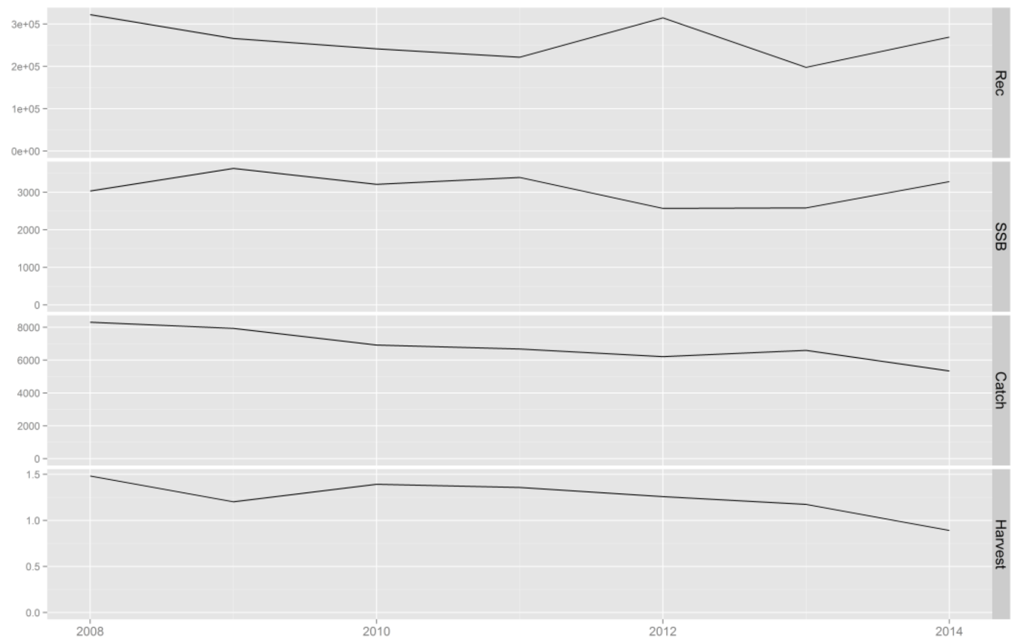


Figure 5.1.1.1.1. European hake in GSA 17 and 18. XSA summary results. SSB and catch are in tonnes, recruitment in thousands of individuals.

Stock advice

The $F_{current}$ is equal to 0.89. This value is larger than $F_{0.1}$ (0.16), chosen as proxy of F_{MSY} and as the exploitation reference point consistent with long term yields (F_{MSY}), which indicates that the stock of hake in GSA 17 and 18 is being fished above F_{MSY}. Catches of hake in 2016 consistent with $F_{0.1}$ (0.16) would not exceed 1813 tonnes.

Basis of the assessment

An XSA analysis were carried out using EU DCF data from 2008 to 2014 integrated with data from Albania, Montenegro and Croatian data before joining EU. The model was tuned using two abundance indices: the MEDITS survey for GSA 17 and the MEDITS survey for GSA 18. Natural mortality was estimated using PRODBIOM. In addition, Yield per Recruit (YPR) analysis was performed for defining $F_{0.1}$ (i.e. proxy of F_{MSY}), short term projections and short term projections by fleet were computed as well as the management strategy evaluation.

Catch options

The catch options for European hake in GSA 17 and 18 are summarized in Table 5.1.1.4.1.

Table 5.1.1.4.1. Hake in GSA 17 and 18. Short term forecast. Basis: F(2015) = mean(Fbar 0-4 2012-2014)= 1.11; R(2015) = geometric mean of the recruitment of the last 3 years; R = 255874 (thousands); SSB(2014) = 3285 t; Catch (2014)= 5345 t.

Rationale	Ffactor	Fbar	Catch 2014	Catch 2015	Catch 2016	Catch 2017	SSB 2016	SSB 2017	Change SSB 2016-2017(%)	Change Catch 2014-2016(%)
Zero catch	0	0.00	5345	7667	0	0	3810	17886	369	-100
High long term yield (F0.1)	0.15	0.162	5345	7667	1813	3764	3810	13822	263	-66
Status quo	1	1.10	5345	7667	7306	7214	3810	3679	-3	37
Different Scenarios	0.1	0.11	5345	7667	1272	2781	3810	15010	294	-76
	0.2	0.22	5345	7667	2363	4640	3810	12639	232	-56
	0.3	0.33	5345	7667	3305	5853	3810	10681	180	-38
	0.4	0.44	5345	7667	4121	6615	3810	9059	138	-23
	0.5	0.55	5345	7667	4832	7066	3810	7714	102	-10
	0.6	0.66	5345	7667	5455	7303	3810	6595	73	2
	0.7	0.77	5345	7667	6003	7394	3810	5663	49	12
	0.8	0.88	5345	7667	6488	7389	3810	4883	28	21
	0.9	0.99	5345	7667	6920	7321	3810	4229	11	29
	1.1	1.21	5345	7667	7653	7084	3810	3215	-16	43
	1.2	1.32	5345	7667	7966	6942	3810	2822	-26	49
	1.3	1.42	5345	7667	8250	6795	3810	2488	-35	54
	1.4	1.53	5345	7667	8510	6648	3810	2203	-42	59
	1.5	1.64	5345	7667	8747	6504	3810	1959	-49	64
	1.6	1.75	5345	7667	8965	6366	3810	1750	-54	68
	1.7	1.86	5345	7667	9166	6235	3810	1568	-59	71
	1.8	1.97	5345	7667	9352	6110	3810	1412	-63	75
	1.9	2.08	5345	7667	9526	5992	3810	1275	-67	78
	2	2.19	5345	7667	9687	5882	3810	1156	-70	81

Reference points

Table 5.1.1.5.1. European hake in GSA 17 and 18. Reference points, values and their technical basis.

Framework	Reference point	Value	Technical basis	Source

MSY approach	MSY $B_{trigger}$			
	F_{MSY}	0.16	$F_{0.1}$ estimated with YPR.	Present assessment
Precautionary approach	B_{lim}	2569	B_{loss}	Present assessment
	B_{pa}	3596	B_{lim}x1.4	Present assessment
	F_{lim}			
	F_{pa}			
EU-GFCM management strategy	SSB_{lower}			
	SSB_{upper}			
	F_{lower}	0.11	Empirical relationship	Present assessment
	F_{upper}	0.23	Empirical relationship	Present assessment

Quality of the assessment

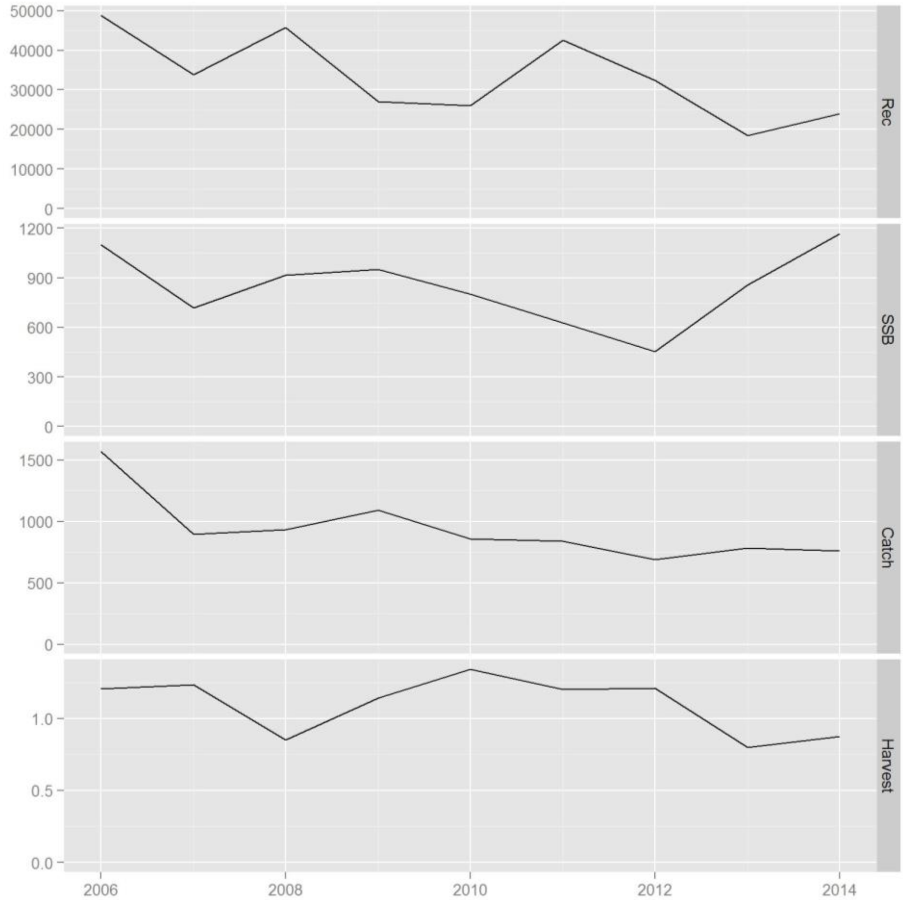
The detailed assessment can be found in section 5.2.1.

5.1.2 SUMMARY SHEET OF HAKE IN GSA 19

Species common name: European hake
Species scientific name: *Merluccius merluccius*
Geographical Sub-area(s) GSA(s): 19

Stock development over time

The SSB showed a decrease from 2008 and 2012 and thereafter an increase with about 1167 t in 2014, being the average along the time series equal to 843 t.
The recruitment shows an overall decreasing trend. The maximum recruitment is reached in 2006 with peaks of similar level observed in 2008 and 2011.
The average F along the time series is 1.10, with a minimum of 0.80 in 2013 and a maximum of 1.23 in 2007. Since 2012, F is decreasing. The current F (0.87) is larger than F_{MSY} (0.18) , which indicates that European hake in GSA 19 is being fished above F_{MSY}.



5.1.2.1.1. Hake in GSA 19. XSA summary results. SSB and catch are in tons, recruitment in 1000s individuals.

Stock advice

The $F_{current}$ is equal to 0.87. This value is larger than $F_{0.1}$ (0.18), chosen as proxy of F_{MSY} and as the exploitation reference point consistent with long term yields (F_{MSY}), which indicates that the stock of hake in GSA 19 is being fished above F_{MSY}. Catches of European hake in GSA 19 in 2016 consistent with F_{MSY} should not exceed 240 t.

Basis of the assessment

The stock assessment was performed applying an Extended Survivor Analysis (XSA) method calibrated with fishery independent survey abundance indices (MEDITS) and CPUE of longlines. In addition, a yield-per-recruit (Y/R) analysis was carried out. Both methods were performed from the size composition of landings and discards, transforming length data to ages using slicing technique. Input data of length frequencies of landings and discards and were taken from DCF. Von Bertalanffy growth parameters and length-weight relationship were taken from parameters estimated for hake in GSA 10. Natural mortality (vector) was estimated using PRODBIOM.

Catch options

Catch options for hake in GSA 19 are summarized in the following table 5.1.2.4.1.

Table 5.1.2.4.1. Hake GSA 19. Short term forecast in different F scenarios computed for *M. merluccius* in GSA 19. Basis: F(2015) = mean (Fbar 0-3 2012-2014)= 0.94; R(2015) = geometric mean of the recruitment of the last 3 years; R = 24284 (thousands); SSB(2014) = 1167 t, Catch (2014)= 759 t.

Rationale	Ffactor	fbar	Catch 2016	Catch 2017	SSB 2017	Change SSB 2016-2017 (%)	Change Catch 2014-2016 (%)
zero	0	0.000	0	0	2707	195	-100
High	0.19	0.18	240	443	2137	132.7	-68.3
Status	1	0.95	857	830	846	-7.8	13.0
Different	0.1	0.09	131	264	2392	160.6	-82.7
	0.2	0.19	249	456	2117	130.6	-67.2
	0.3	0.28	355	594	1877	104.4	-53.3
	0.4	0.38	450	690	1666	81.5	-40.7
	0.5	0.47	535	755	1482	61.4	-29.4
	0.6	0.57	613	797	1320	43.7	-19.2
	0.7	0.66	683	821	1178	28.3	-9.9
	0.8	0.76	747	833	1053	14.7	-1.6
	0.9	0.85	805	835	943	2.7	6.1
	1.1	1.04	906	821	761	-17.1	19.4
	1.2	1.14	950	808	686	-25.3	25.2
	1.3	1.23	990	794	619	-32.6	30.5
	1.4	1.32	1027	778	560	-39.0	35.4
	1.5	1.42	1062	762	508	-44.7	40.0
	1.6	1.51	1093	746	461	-49.8	44.1
	1.7	1.61	1123	730	420	-54.3	48.0
	1.8	1.70	1150	714	383	-58.3	51.6
	1.9	1.80	1175	699	350	-61.8	54.9
	2	1.89	1199	685	321	-65.0	58.0

Reference points

Reference points for hake in GSA19 are summarized in the following table 5.1.2.5.1.

Table 5.1.2.5.1. Hake in GSA 19. Reference points, values and their technical basis.

Framework	Reference	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$			
	F_{MSY}	0.18	$F_{0.1}$ estimated with Yield-per-Recruit	Present
Precautionary approach	B_{lim}	452	B_{loss}	Present
	B_{pa}			
	F_{lim}			
	F_{pa}			
EU-GFCM management	SSB_{lower}			
	SSB_{upper}			

strategy	F_{lower}	0.12	Empirical relationship	Present
	F_{upper}	0.25	Empirical relationship	Present

Quality of the assessment

The detailed assessment can be found in section 5.2.2.

5.1.3 SUMMARY SHEET OF RED MULLET IN GSA 17-18

Species common name: Red Mullet
Species scientific name: *Mullus barbatus*
Geographical Sub-area(s) GSA(s): 17-18

Stock development over time

SSB shows an increasing trend from 2010 to 2014. The last estimate of SSB in 2014 is 6635 tons. Regarding the recruitment, it was observed a general increasing trend until 2013 when recruitment reached a peak; after that there was a decrease in 2014. Fishing mortality decreased from 2012 reaching the minimum value of 0.54 in 2014.

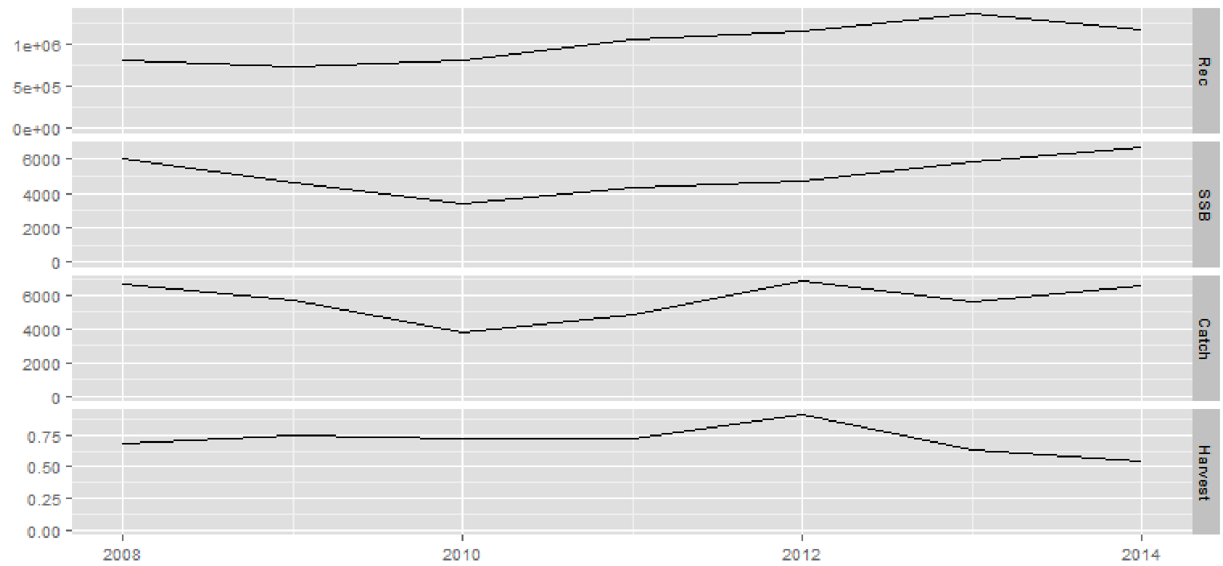


Figure 5.1.3.1.1. Red mullet in GSA 17 and 18. XSA summary results. SSB and catch are in tonnes, recruitment in thousands of individuals.

Stock advice

The $F_{current}$ is equal to 0.54. This value is greater than $F_{0.1}$ (0.41), used as proxy of F_{MSY} and as the exploitation reference point consistent with long term yields (F_{MSY}), which indicates that the stock of red mullet in GSA 17 and 18 is fished above F_{MSY}. Catches of Red mullet in GSA 17-18 in 2016 consistent with F_{MSY} should not exceed 4280 t.

Basis of the assessment

An XSA analysis were carried out using EU DCF data from 2008 to 2014 integrated with data from Albania, Montenegro and Croatian data before joining EU. The model was tuned using two abundance indexes: the MEDITS survey for GSA 17 and the MEDITS survey for GSA 18. Natural mortality was estimated using PRODBIOM. Moreover, Yield per Recruit (YPR) analysis was performed for defining $F_{0.1}$ (as proxy of F_{MSY}), short term projections and short term projections by fleet were computed.

Catch options

The catch options for Red mullet in GSA 17 and 18 are summarized in Table 5.1.3.4.1.

Table 5.1.3.4.1. Red mullet in GSA 17 and 18 - Short term forecast in different F scenarios.

Rationale	Ffactor	Fbar	Catch 2015	Catch 2016	Catch 2017	SSB 2016	SSB 2017	Change SSB 2016-2017(%)	Change Catch 2014-2016(%)
Zero catch	0	0.00	7587	0	0	9103	14153	55.5	-100.0
High long term yield (F0.1)	0.607	0.41	7587	4280	4558	7177	7665	6.8	-35.2
Status quo	0.1	0.07	7587	840	1145	8748	12739	45.6	-87.3
Different Scenarios	0.2	0.14	7587	1620	2097	8409	11484	36.6	-75.5
	0.3	0.20	7587	2346	2887	8085	10371	28.3	-64.5
	0.4	0.27	7587	3021	3541	7776	9382	20.7	-54.3
	0.5	0.34	7587	3650	4082	7480	8503	13.7	-44.7
	0.6	0.41	7587	4238	4528	7198	7719	7.2	-35.8
	0.7	0.47	7587	4787	4895	6928	7021	1.3	-27.5
	0.8	0.54	7587	5302	5195	6670	6398	-4.1	-19.7
	0.9	0.61	7587	5784	5441	6423	5841	-9.1	-12.4
	1	0.68	7587	6237	5641	6187	5343	-13.6	-5.5
	1.1	0.74	7587	6664	5803	5961	4896	-17.9	0.9
	1.2	0.81	7587	7065	5933	5745	4496	-21.7	7.0
	1.3	0.88	7587	7443	6037	5538	4137	-25.3	12.7
	1.4	0.95	7587	7801	6120	5341	3814	-28.6	18.1
	1.5	1.01	7587	8139	6185	5151	3524	-31.6	23.3
	1.6	1.08	7587	8459	6235	4970	3262	-34.4	28.1
	1.7	1.15	7587	8762	6274	4796	3026	-36.9	32.7
	1.8	1.22	7587	9050	6303	4629	2813	-39.2	37.1
	1.9	1.29	7587	9324	6324	4470	2621	-41.4	41.2
	2	1.35	7587	9585	6339	4317	2447	-43.3	45.2

Reference points

Table 5.1.3.5.1. Red mullet in GSA 17 and 18 - Reference points, values and their technical basis.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$			
	F_{MSY}	0.41	$F_{0.1}$ estimated with YPR.	Present assessment
Precautionary approach	B_{lim}	3438	B_{loss}	Present assessment
	B_{pa}	4814	B_{lim}x1.4	Present assessment
	F_{lim}			
	F_{pa}			
EU-GFCM management strategy	SSB_{lower}			
	SSB_{upper}			
	F_{lower}	0.27	Empirical relationship	Present assessment
	F_{upper}	0.56	Empirical relationship	Present assessment

Quality of the assessment

The detailed assessment can be found in section 5.2.3.

5.1.4 SUMMARY SHEET OF RED MULLET IN GSA 19

Species common name: Red Mullet
Species scientific name: *Mullus barbatus*
Geographical Sub-area(s) GSA(s): 19

Stock development over time

The SSB showed a decreasing trend, even if in 2010 it increased again to a value equal to 972 t and decreased thereafter until 2014 reaching the lower value of the time series (496 t).
The recruitment show a peak in 2009 and after that year slightly decreases until 2014.
The F along the time series is on average 1.49, with a minimum of 0.99 in 2014 and a maximum of 2.05 in 2006. The current F (0.99) is larger than F_{MSY} (0.45), which indicates that red mullet in GSA 19 is being fished above F_{MSY}.

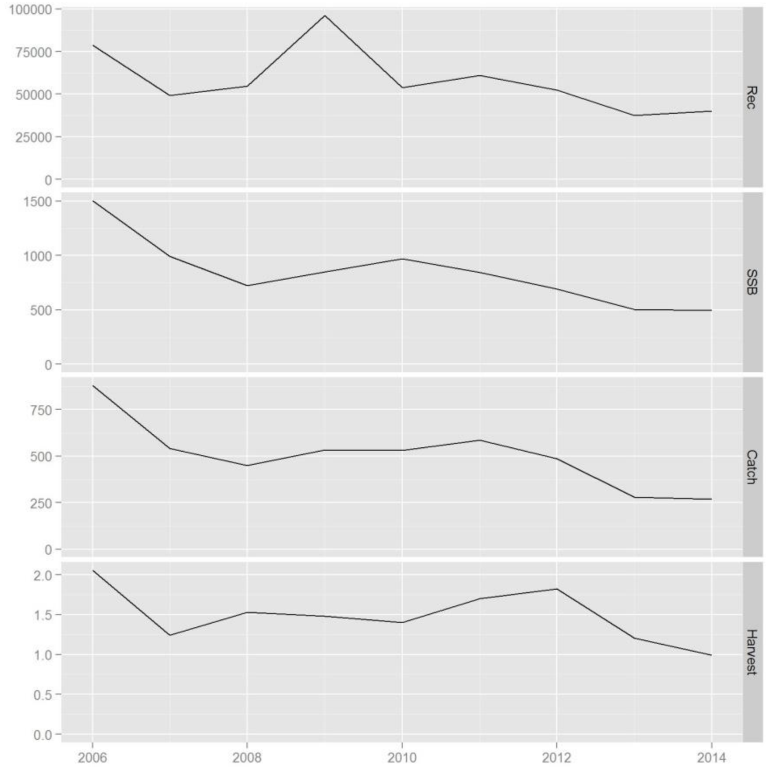


Figure 5.1.4.1.1. Red mullet in GSA 19. XSA summary results. SSB and catch are in tonnes, recruitment in thousands of individuals.

Stock advice
The $F_{current}$ is equal to 0.99. This value is larger than $F_{0.1}$ (0.45), chosen as proxy of F_{MSY} and as the exploitation reference point consistent with long term yields (F_{MSY}), which indicates that the stock of red mullet in GSA 19 is being fished above F_{MSY}. Catches of red mullet in GSA 19 in 2016 consistent with F_{MSY} should not exceed 187 t.

Basis of the assessment

The stock assessment was performed applying an Extended Survivor Analysis (XSA) method calibrated with fishery independent survey abundance indices (MEDITS). In addition, a yield-per-recruit (Y/R) analysis was carried out. Both methods were performed from the size composition of landings and discards, transforming length data to ages using slicing technique. Input data of length frequencies of landings and discards and were taken from DCF. Von Bertalanffy growth parameters and length-weight relationship were taken from parameters estimated for hake in GSA 19. Natural mortality (vector) was estimated using PROBIOM.

Catch options

Catch options are summarized in the following table 5.1.4.4.

Table 5.1.4.4.1. Short term forecast in different F scenarios computed for red mullet in GSA 19. Basis: F(2015) = mean(F_{bar}0-2 2012-2014)= 1.3; R(2014) = geometric mean of the recruitment of the last 3years = 42889 (thousands); SSB(2014) = 496 t, Catch (2014)= 269 t.

Rationale	Ffactor	Fbar	Catch 2016	Catch 2017	SSB 2017	Change SSB 2016-2017(%)	Change Catch 2014-2016(%)
zero catch	0	0	0	0	1190	113.2	-100.0
High long-term yield (F0.1)	0.34	0.44	187	269	855	53.3	-30.7
Status quo	1	1.30	377	374	553	-1.0	40.2
Different scenarios	0.1	0.13	66	114	1069	91.5	-75.6
	0.2	0.26	122	195	968	73.5	-54.8
	0.3	0.39	170	252	884	58.4	-36.8
	0.4	0.52	212	293	813	45.6	-21.3
	0.5	0.65	248	321	752	34.8	-7.7
	0.6	0.78	281	341	700	25.5	4.2
	0.7	0.91	309	355	656	17.5	14.7
	0.8	1.04	334	364	617	10.5	24.1
	0.9	1.17	357	370	583	4.4	32.5
	1.1	1.43	396	377	526	-5.8	47.1
	1.2	1.56	413	378	501	-10.1	53.4
	1.3	1.68	429	379	480	-14.0	59.3
	1.4	1.81	443	379	460	-17.6	64.7
	1.5	1.94	457	379	441	-20.9	69.7
	1.6	2.07	469	379	425	-23.9	74.3
	1.7	2.20	481	378	409	-26.7	78.7
	1.8	2.33	492	377	395	-29.3	82.8
	1.9	2.46	503	377	381	-31.7	86.7
	2	2.59	513	376	369	-34.0	90.4

Reference points

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$			
	F_{MSY}	0.45	$F_{0.1}$ estimated with Yield-per-Recruit analyses	Present assessment

Precautionary approach	B_{lim}	496	B_{loss}	Present assessment
	B_{pa}	695	B_{lim}x1.4	
	F_{lim}			
	F_{pa}			
EU-GFCM management strategy	SSB_{lower}			
	SSB_{upper}			
	F_{lower}	0.30	Empirical relationship	Present assessment
	F_{upper}	0.62	Empirical relationship	Present assessment

Quality of the assessment

The detailed assessment can be found in section 5.2.4.

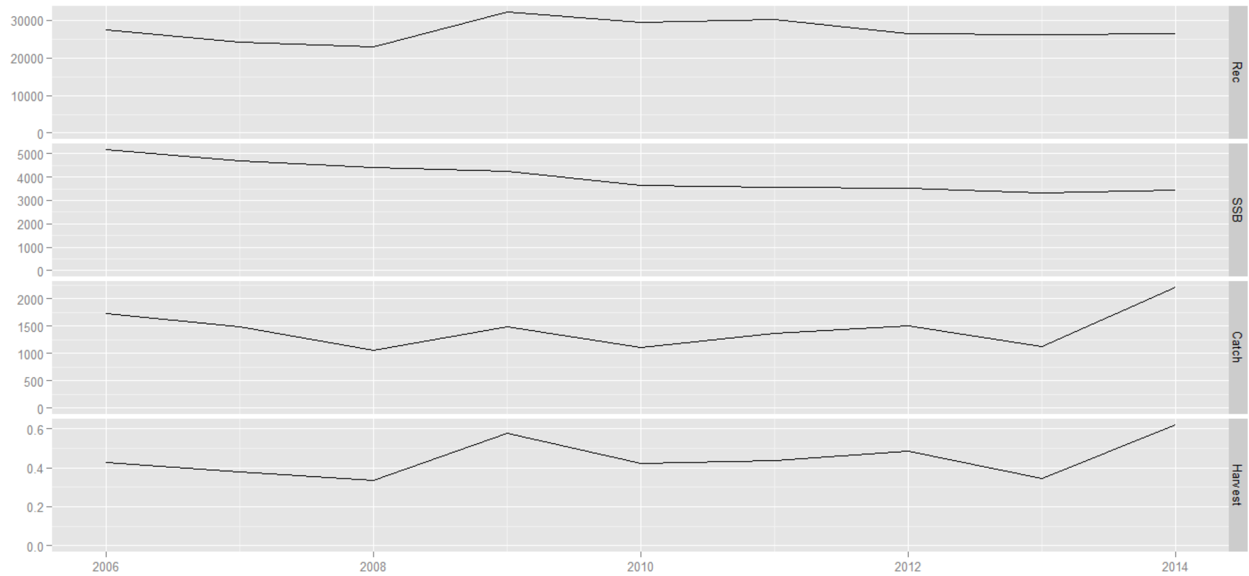
5.1.5 SUMMARY SHEET OF COMMON SOLE IN GSA 17

Species common name: Common Sole
Species scientific name: *Solea solea*
Geographical Sub-area GSA: 17

Stock development over time

Stock assessment has been carried out applying an Extended Survivors Analysis (XSA) and a Statistical Catch at age using Stock Synthesis 3 (SS3). The final advice is based on the output of the final SS3 model.

Exploitation increased from the beginning of the time-series, with a more pronounced increase after 2000. In the period 2006-2013 the F_{bar} showed important oscillations around a value of 0.5. In 2014 the value of mean fishing mortality (F_{bar} 0-4) increased toward 0.62, the partial F for each fleet is 0.37 for the Italian trawlers, 0.19 for the Italian gill netters and 0.06 for the Slovenian and Croatian set netters. Recruitment varied without any trend in the years 1970-2012, reaching the minimum in 2008, followed by an increase in 2009; after that there was a general decrease till to 2014. The SSB showed a strong decrease since the beginning of the series. The last estimate of SSB in 2014 is around 3545 tons.



Common Sole in GSA 17. SS3 summary results. SSB and catch are in tonnes, recruitment in thousands of individuals.

Stock advice

The current F (0.62) is larger than $F_{0.1}$ (0.26), chosen as proxy of F_{MSY} and as the exploitation reference point consistent with high long term yields, which indicates common sole in GSA 17 is being fished above F_{MSY}. Catches of common sole in GSA 17 in 2016 consistent with F_{MSY} should not exceed 807 tonnes.

Basis of the assessment

The stock of common sole in GSA 17 was assessed applying Statistical Cathc at age method using SS3 calibrated with fishery independent survey abundance indices (SoleMon in GSA 17). Input data on landings, discards and length frequencies were taken from EU DCF data and other sources.

Catch options

The catch options for Common Sole in GSA 17 summarized in Table 5.1.5.4.1.

Table 5.1.5.4.1. Common sole in GSA 17 – Short term forecast in different F scenarios. Basis: F(2015) = mean(Fbar0-4 2012-2014)= 0.48; R(2015) = geometric mean of the recruitment of the last 3 years; R = 26,272.2 (thousands); SSB(2014) = 3,545 t, Catch (2014)= 2,212 t.

Rationale	Ffactor	Fbar	Catch 2014	Catch 2015	Catch 2016	Catch 2017	SSB 2016	SSB 2017	Change in SSB 2016-2017(%)	Change in Catch 2014-2016(%)
0 catch	0.00	0.00	2212	1298	0	0	2579	3955	53.3	-100.0
High long term yield ($F_{0.1}$)	0.56	0.26	2212	1298	807	935	2579	3016	16.9	-63.5
Status quo	1.00	0.48	2212	1298	1279	1283	2579	2486	-3.6	-42.2
Scenarios	0.10	0.05	2212	1298	166	226	2579	3759	45.7	-92.5
	0.20	0.09	2212	1298	322	423	2579	3576	38.6	-85.4
	0.30	0.14	2212	1298	468	593	2579	3405	32.0	-78.8
	0.40	0.19	2212	1298	606	741	2579	3246	25.9	-72.6
	0.50	0.23	2212	1298	735	869	2579	3098	20.1	-66.7
	0.60	0.28	2212	1298	857	979	2579	2959	14.7	-61.2
	0.70	0.33	2212	1298	972	1073	2579	2829	9.7	-56.0
	0.80	0.38	2212	1298	1080	1155	2579	2707	5.0	-51.2
	0.90	0.42	2212	1298	1183	1224	2579	2593	0.5	-46.5
	1.10	0.52	2212	1298	1371	1332	2579	2386	-7.5	-38.0
	1.20	0.56	2212	1298	1457	1374	2579	2291	-11.2	-34.1
	1.30	0.61	2212	1298	1539	1409	2579	2202	-14.6	-30.4
	1.40	0.66	2212	1298	1617	1438	2579	2119	-17.8	-26.9
	1.50	0.70	2212	1298	1691	1461	2579	2040	-20.9	-23.6
	1.60	0.75	2212	1298	1761	1479	2579	1966	-23.8	-20.4
	1.70	0.80	2212	1298	1828	1494	2579	1896	-26.5	-17.4
	1.80	0.84	2212	1298	1891	1505	2579	1830	-29.0	-14.5
	1.90	0.89	2212	1298	1952	1513	2579	1768	-31.5	-11.8
	2.00	0.94	2212	1298	2009	1518	2579	1708	-33.8	-9.2

Reference points

Table 5.1.5.5.1. Common Sole in GSA 17 - Reference points, values and their technical basis.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$			
	F_{MSY}	0.26	$F_{0.1}$ estimated with YPR.	Present assessment
Precautionary approach	B_{lim}	3445	B_{loss}	Present assessment
	B_{pa}			
	F_{lim}			
	F_{pa}			

EU-GFCM management strategy	SSB_{lower}			
	SSB_{upper}			
	F_{lower}	0.18	Empirical relationship	Present assessment
	F_{upper}	0.36	Empirical relationship	Present assessment

Quality of the assessment

The detailed assessment can be found in section 5.2.5.

5.1.6 SUMMARY SHEET OF NORWAY LOBSTER IN GSA 17-18

Species common name: Norway Lobster
Species scientific name: *Nephrops norvegicus*
Geographical Sub-area(s) GSA(s): 17-18

Stock development over time

The assessment was carried out using an XSA model. The assessment was not accepted and thus short term forecast and advice were not provided. Nevertheless, the following sections describes the results as obtained by the XSA model.

Recruitment decreased from 2008 to 2012 followed by a slight increase in the final two years; SSB decreased until 2011 and then stabilised; catches have been decreasing since 2008. When considering ages 1-4, average fishing mortality has mostly been above 0.8 y^{-1}, with the exception of 2012 and 2014 which are lower (Figs. 5.1.6.1.1 and 5.1.6.1.2). When considering ages 0-4, average fishing mortality follows the same trend as F (1-4) but with lower values, all above 0.5 y^{-1} (Fig. 5.1.6.1.2).

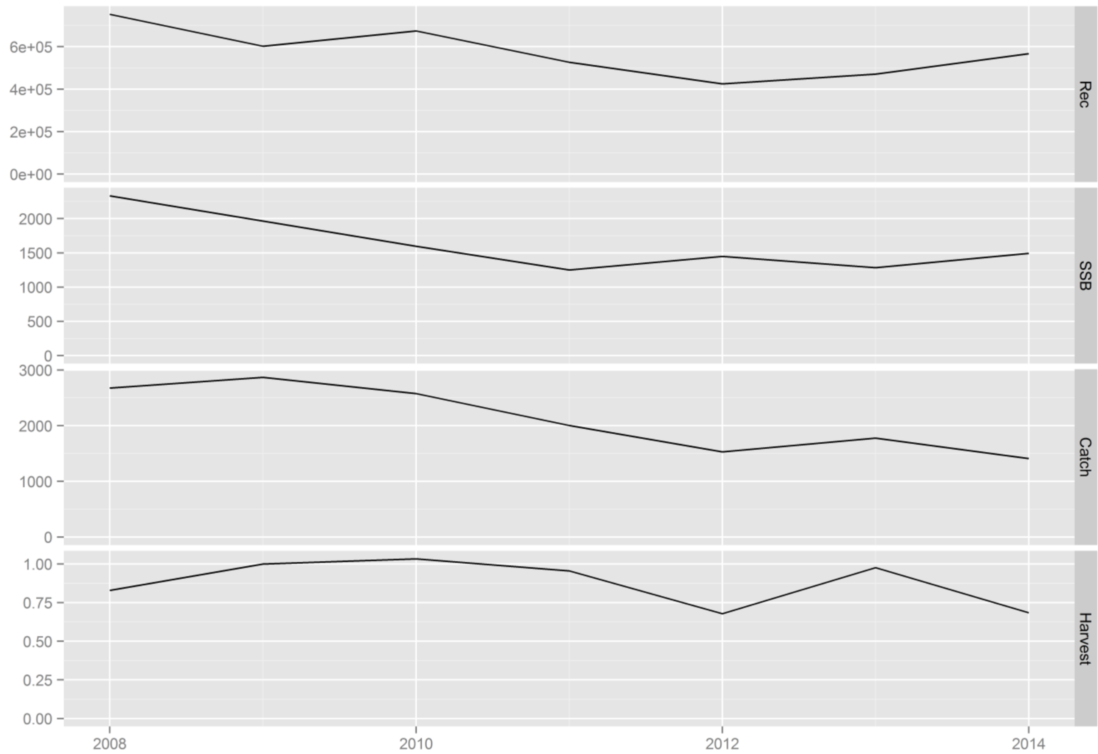


Figure 5.1.6.1.1. Norway lobster in GSA 17 and 18. XSA summary results. SSB and catches are in tonnes, recruitment in thousands of individuals.

Stock advice

The assessment was not considered valid (see Data issue chapter in section 5.2.6.9) and thus no advice was provided.

Basis of the assessment

An XSA analysis was carried out using EU DCF data from 2008 to 2014 integrated with data from Croatia before joining EU. The model was tuned using two abundance indices: the MEDITS survey for GSA 17 and the MEDITS survey for GSA 18. Natural mortality was estimated using PRODBIOM.

Catch options

Short terms projections were not carried out as the advice was no accepted (see sections 5.2.6.9 and 5.1.6.6)

Reference points

Table 5.1.6.5.1. Norway lobster in GSA 17 and 18. Reference points, values and their technical basis.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$			
	F_{MSY}			
Precautionary approach	B_{lim}			
	B_{pa}			
	F_{lim}			
	F_{pa}			
EU-GFCM management strategy	SSB_{lower}			
	SSB_{upper}			
	F_{lower}			
	F_{upper}			

Quality of the assessment

The detailed assessment can be found in section 5.2.6.

5.1.7 SUMMARY SHEET OF SPOT-TAIL MANTIS SHRIMP IN GSA 17

Species common name: Spot-tail mantis shrimp
Species scientific name: *Squilla mantis*
Geographical Sub-area(s) GSA(s): 17

Stock development over time

According to the XSA results, SSB estimates decrease from a maximum of 15414 tonnes in 2008 to a minimum of 10452 tonnes in 2013; SSB in 2014 is equal to 11536 tonnes. The fishing mortality decreases from 2010 to 2013, and then increases again in 2014, with a F of 0.63 in 2014. Recruitment, after a decrease from 2008 to 2011, is quite stable in the last 4 years with a value of 836,021 in 2014.

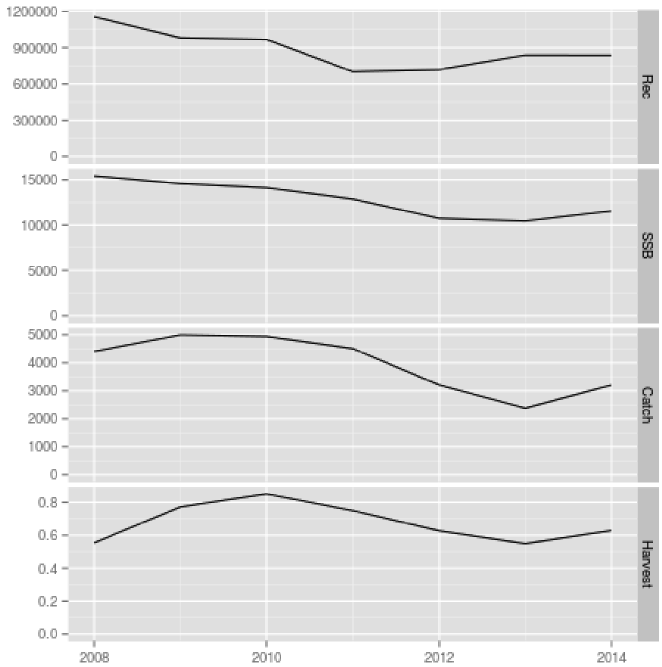


Figure 5.1.7.1.1. Spot-tail mantis shrimp in GSA 17. XSA summary results. SSB and catches are in tonnes, recruitment in thousands of individuals.

Stock advice

The current F (0.63) is larger than $F_{0.1}$ (0.48), chosen as proxy of F_{MSY} and as the exploitation reference point consistent with high long term yields, which indicates that spot-tail mantis shrimp in GSA 17 is exploited above F_{MSY}. Catches of spot-tail mantis shrimp in 2016 consistent with F_{MSY} (0.48) should not exceed 3032 tonnes.

Basis of the assessment

An XSA analysis was performed using 2008-2014 DCF data using catch at age data provided and tuned with fishery independent abundance indices (SOLEMON survey). A vector of natural mortality was obtained applying PRODBIOM. In addition, Yield per Recruit (YPR) analysis was performed for the estimation of $F_{0.1}$ (i.e. proxy of F_{MSY}).

Catch options

The catch options for the spot-tail mantis shrimp in GSA 17 are summarized in Table 5.1.7.4.1.

Table 5.1.7.4.1. Spot-tail mantis shrimp in GSA17. Short term forecast. Basis: F(2015) = mean(Fbar1-3 2012-2014)= 0.59; R(2015) = geometric mean of the recruitment of the last 3 years; R = 836,020 (thousands); SSB(2014) = 11,536 t, Catch (2014)= 3,205 t.

Rationale	Ffactor	Fbar	Catch 2014	Catch 2015	Catch 2016	Catch 2017	SSB 2016	SSB 2017	Change in SSB 2016-2017(%)	Change in Catch 2014-2016(%)
0 catch	0	0	3205	3430	0	0	12045	15581	29.36	-100
High long term yield ($F_{0.1}$)	0.82	0.48	3205	3430	3032	3223	12045	12534	4.07	-5.42
Status quo	1	0.59	3205	3430	3509	3520	12045	12072	0.23	9.46
Scenarios	0.1	0.06	3205	3430	455	645	12045	15115	25.49	-85.82
	0.2	0.12	3205	3430	882	1197	12045	14679	21.87	-72.5
	0.3	0.18	3205	3430	1283	1668	12045	14272	18.49	-59.98
	0.4	0.24	3205	3430	1660	2070	12045	13892	15.34	-48.21
	0.5	0.29	3205	3430	2015	2414	12045	13537	12.39	-37.13
	0.6	0.35	3205	3430	2350	2708	12045	13205	9.63	-26.69
	0.7	0.41	3205	3430	2665	2960	12045	12893	7.05	-16.86
	0.8	0.47	3205	3430	2962	3176	12045	12602	4.63	-7.58
	0.9	0.53	3205	3430	3243	3361	12045	12329	2.36	1.18
	1.1	0.65	3205	3430	3760	3656	12045	11831	-1.77	17.29
	1.2	0.71	3205	3430	3997	3773	12045	11605	-3.65	24.71
	1.3	0.76	3205	3430	4222	3874	12045	11392	-5.42	31.73
	1.4	0.82	3205	3430	4436	3961	12045	11192	-7.08	38.39
	1.5	0.88	3205	3430	4638	4036	12045	11003	-8.65	44.71
	1.6	0.94	3205	3430	4831	4102	12045	10825	-10.13	50.72
	1.7	1	3205	3430	5014	4158	12045	10656	-11.53	56.43
	1.8	1.06	3205	3430	5188	4208	12045	10497	-12.85	61.87
	1.9	1.12	3205	3430	5354	4251	12045	10347	-14.09	67.05
	2	1.18	3205	3430	5513	4289	12045	10205	-15.28	71.99

Reference points

Table 5.1.7.5.1. Mantis shrimp in GSA 17. Reference points, values and their technical basis.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$			
	F_{MSY}	0.48	$F_{0.1}$ estimated with YPR.	Present assesment
Precautionary	B_{lim}	10452	B_{loss}	Present assessment

approach	B_{pa}			
	F_{lim}			
	F_{pa}			
EU-GFCM management strategy	SSB_{lower}			
	SSB_{upper}			
	F_{lower}	0.32	Empirical relationship	Present assessment
	F_{upper}	0.66	Empirical relationship	Present assessment

Quality of the assessment

The detailed assessment can be found in section 5.2.7.

5.1.8 SUMMARY SHEET OF SPOT-TAIL MANTIS SHRIMP IN GSA 18

Species common name: Spot-tail mantis shrimp
Species scientific name: *Squilla mantis*
Geographical Sub-area(s) GSA(s): 18

Stock development over time

According to the XSA results (Fig. 5.1.8.1.1), SSB estimates increased from 2011 to 2013 (3400 t) to decrease again at about 1680 t in 2014. The fishing mortality shows a significant decreasing trend (r^2=0.47) from 2007 (F=1.9) to 2014 (F=1.0). Recruitment ranges widely between about 100 and 430 million in the period 2007-2014.

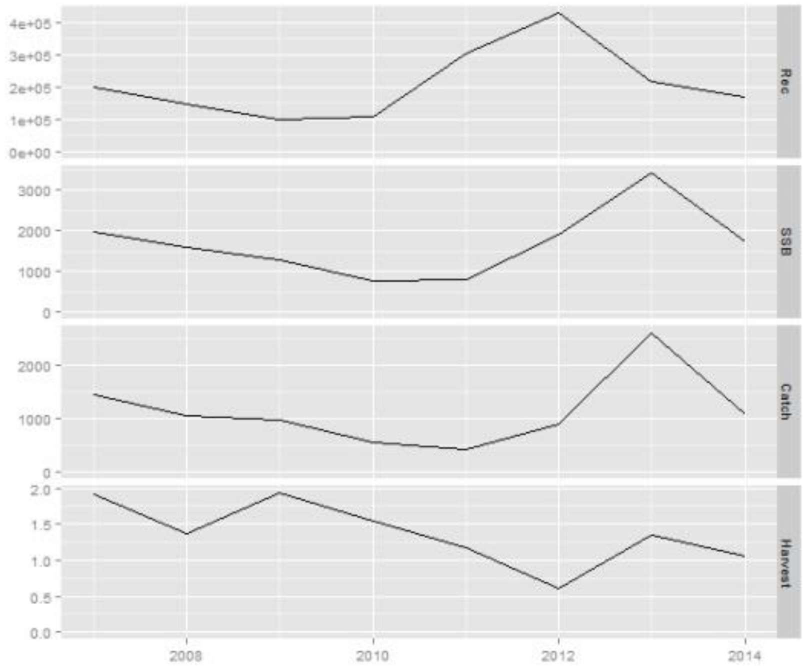


Figure 5.1.8.1.1. Spot-tail mantis shrimp in GSA 18. XSA summary results. SSB and catch are in tonnes, recruitment in thousands of individuals.

Stock advice

The current F_{0-4} (1.0) is larger than $F_{0.1}$ (0.43), chosen as proxy of F_{MSY} and as the exploitation reference point consistent with high long term yields, which indicates that spot-tail mantis shrimp in GSA 18 is being fished above F_{MSY}. Catches of spot-tail mantis shrimp in 2016 consistent with F_{MSY} should not exceed 615 t.

Basis of the assessment
Stock assessment has been performed applying Extended Survivors Analysis (XSA) to the official DCF Italian data of catch at age for the period 2007-2014. Discard data before 2009 were reconstructed based on the data available from 2009 to 2014.

Catch options
Catch options are summarized in the following table 5.1.8.4.1

Table 5.1.8.4.1. Spot-tail mantis shrimp in GSA 18. Short term forecast in different F scenarios Basis: F(2015) = geometric mean (F_{bar} 0-4+ 2012-2014)= 0.95; R(2015) = geometric mean of the recruitment of the last 3 years = 251 million; SSB(2014) = 1714 t, Catch (2014)= 1082.6 t.

Rationale	Ffactor	Fbar	Catch 2014	Catch 2015	Catch 2016	Catch 2017	SSB 2016	SSB 2017	Change SSB 2016 - 2017(%)	Change catch 2014 - 2016(%)
0 catch	0	0	1082.6	918.5	0	0	1743.4	3200.4	83.9	-100
High long term yield (F01)	0.46	0.43	1082.6	918.5	615.5	879.5	1743.4	2456.4	40.9	-43.1
Status quo	1	0.95	1082.6	918.5	1097.1	1201.9	1743.4	1908.5	9.5	1.3
Scenarios	0.1	0.09	1082.6	918.5	159.0	285.1	1743.4	3004.9	72.4	-85.3
	0.2	0.19	1082.6	918.5	303.7	508.3	1743.4	2828.7	62.2	-71.9
	0.3	0.28	1082.6	918.5	435.8	683.1	1743.4	2669.7	53.1	-59.7
	0.4	0.38	1082.6	918.5	556.4	819.9	1743.4	2526.2	44.9	-48.6
	0.5	0.47	1082.6	918.5	666.7	927.2	1743.4	2396.4	37.5	-38.4
	0.6	0.57	1082.6	918.5	767.9	1011.3	1743.4	2278.9	30.7	-29.1
	0.7	0.66	1082.6	918.5	860.7	1077.2	1743.4	2172.4	24.6	-20.5
	0.8	0.75	1082.6	918.5	946.0	1129.0	1743.4	2075.9	19.1	-12.6
	0.9	0.85	1082.6	918.5	1024.6	1169.8	1743.4	1988.2	14.0	-5.4
	1.1	1.04	1082.6	918.5	1164.1	1227.4	1743.4	1835.9	5.3	7.5
	1.2	1.13	1082.6	918.5	1226.1	1247.6	1743.4	1769.7	1.5	13.3
	1.3	1.23	1082.6	918.5	1283.6	1263.8	1743.4	1709.3	-2.0	18.6
	1.4	1.32	1082.6	918.5	1337.0	1276.8	1743.4	1654.1	-5.1	23.5
	1.5	1.42	1082.6	918.5	1386.6	1287.4	1743.4	1603.5	-8.0	28.1
	1.6	1.51	1082.6	918.5	1432.9	1296.0	1743.4	1557.2	-10.7	32.4
	1.7	1.60	1082.6	918.5	1476.2	1303.3	1743.4	1514.6	-13.1	36.4
	1.8	1.70	1082.6	918.5	1516.7	1309.4	1743.4	1475.5	-15.4	40.1
	1.9	1.79	1082.6	918.5	1554.6	1314.6	1743.4	1439.4	-17.4	43.6
	2	1.89	1082.6	918.5	1590.2	1319.1	1743.4	1406.1	-19.3	46.9

Reference points

Table 5.1.8.5.1. Spot-tail mantis shrimp in GSA 18. Reference points, values and their technical basis.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$			
	F_{MSY}	0.43	$F_{0.1}$ estimated with YPR.	Present assessment

Precautionary approach	B_{lim}	848	B_{loss}	Present assessment
	B_{pa}			
	F_{lim}			
	F_{pa}			
EU-GFCM management strategy	SSB_{lower}			
	SSB_{upper}			
	F_{lower}	0.29	Empirical relationship	Present assessment
	F_{upper}	0.59	Empirical relationship	Present assessment

Quality of the assessment

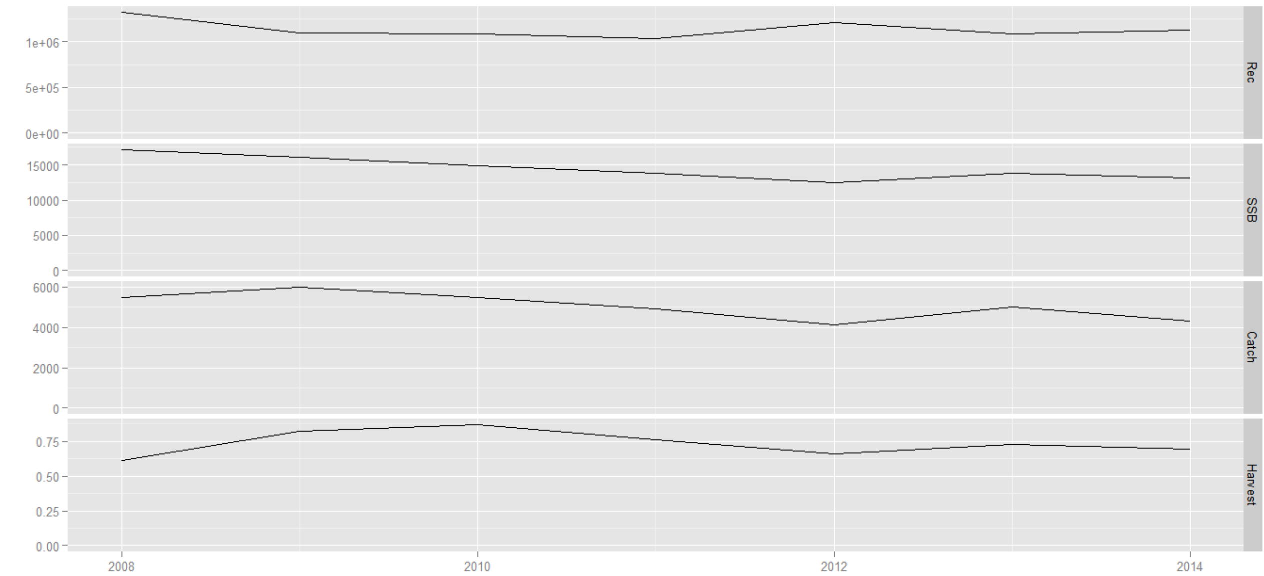
The detailed assessment can be found in section 5.2.8.

5.1.9 SUMMARY SHEET OF SPOT-TAIL MANTIS SHRIMP IN GSA 17-18

Species common name: Spot-tail mantis shrimp
Species scientific name: *Squilla mantis*
Geographical Sub-area(s) GSA(s): 17-18

Stock development over time

The SSB showed a decreasing trend from 2008 (17127 t) to 2014 (13176 t). The recruitment estimated for 2014 is similar to the values observed in the previous years. The current F (0.69) is larger than F_{MSY} (0.56), which indicates that spot-tail mantis shrimp in GSA 17-18 is is being fished above F_{MSY}.



Spot-tail mantis shrimp in GSA 17-18. XSA summary results. SSB and catch are in tonnes, recruitment in 1000s individuals.

Stock advice
The current F (0.69) is larger than $F_{0.1}$ (0.56), chosen as proxy of F_{MSY} and as the exploitation reference point consistent with high long term yields, which indicates that spot-tail mantis shrimp in GSA 17-18 is being fished above F_{MSY}. Catches of spot-tail mantis shrimp in 2016 consistent with F_{MSY} should not exceed 4189 tonnes.

Basis of the assessment
The stock of spot-tail mantis shrimp in GSA 17-18 was assessed applying an Extended Survivor Analysis (XSA) method calibrated with fishery independent survey abundance indices (SoleMon in GSA 17). Input data on landings, discards and length frequencies were taken from EU DCF data.

Catch options
Catch options are summarized in the following table 5.1.9.4.1.

Table 5.1.9.4.1. Spot-tail mantis shrimp in GSA17-18 – Short term forecast in different F scenarios. Basis: F(2015) = mean(Fbar1-3 2012-2014)= 0.69; R(2015) = geometric mean of the recruitment of the last 3 years; R = 1140084 (thousands); SSB(2014) = 13176 t, Catch (2014)= 4288 t.

Rationale	Ffactor	Fbar	Catch 2014	Catch 2015	Catch 2016	Catch 2017	SSB 2016	SSB 2017	Change in SSB 2016-2017(%)	Change in Catch 2014-2016(%)
0 catch	0.00	0.00	4288	4863	0	0	13761	18958	37.8	-100.0
High long term yield ($F_{0.1}$)	0.81	0.56	4288	4863	4189	4496	13761	14549	5.7	-2.3
Status quo	1.00	0.69	4288	4863	4907	4929	13761	13817	0.4	14.4
Scenarios	0.10	0.07	4288	4863	636	920	13761	18277	32.8	-85.2
	0.20	0.14	4288	4863	1234	1702	13761	17640	28.2	-71.2
	0.30	0.21	4288	4863	1795	2367	13761	17046	23.9	-58.1
	0.40	0.28	4288	4863	2322	2932	13761	16490	19.8	-45.8
	0.50	0.35	4288	4863	2819	3413	13761	15970	16.1	-34.3
	0.60	0.41	4288	4863	3286	3821	13761	15482	12.5	-23.4
	0.70	0.48	4288	4863	3727	4169	13761	15026	9.2	-13.1
	0.80	0.55	4288	4863	4143	4464	13761	14597	6.1	-3.4
	0.90	0.62	4288	4863	4535	4715	13761	14195	3.2	5.8
	1.10	0.76	4288	4863	5258	5110	13761	13461	-2.2	22.6
	1.20	0.83	4288	4863	5590	5265	13761	13126	-4.6	30.4
	1.30	0.90	4288	4863	5906	5396	13761	12811	-6.9	37.7
	1.40	0.97	4288	4863	6205	5507	13761	12513	-9.1	44.7
	1.50	1.04	4288	4863	6489	5602	13761	12232	-11.1	51.3
	1.60	1.10	4288	4863	6759	5682	13761	11967	-13.0	57.6
	1.70	1.17	4288	4863	7016	5751	13761	11716	-14.9	63.6
	1.80	1.24	4288	4863	7260	5809	13761	11478	-16.6	69.3
	1.90	1.31	4288	4863	7493	5859	13761	11253	-18.2	74.8
	2.00	1.38	4288	4863	7716	5901	13761	11039	-19.8	79.9

Reference points

Table 5.1.9.5.1. Spot-tail mantis shrimp in GSA17-18. Reference points, values and their technical basis.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$			
	F_{MSY}	0.56	$F_{0.1}$ estimated with YPR.	Present assessment
Precautionary approach	B_{lim}	12478	B_{loss}	Present assessment
	B_{pa}			
	F_{lim}			
	F_{pa}			
EU-GFCM management strategy	SSB_{lower}			
	SSB_{upper}			
	F_{lower}	0.37	Empirical relationship	Present assessment
	F_{upper}	0.76	Empirical relationship	Present assessment

Quality of the assessment

The detailed assessment can be found in section 5.2.9.

5.1.10 SUMMARY SHEET OF DEEP-WATER ROSE SHRIMP IN GSA 18

Species common name: Deep-water rose shrimp
Species scientific name: *Parapenaeus longirostris*
Geographical Sub-area(s) GSA(s): 18

Stock development over time

State of the adult abundance and biomass

The SSB shows a general slightly decreasing trend, while it is increasing in the last few year. In the time series 2007-2014, SSB shows an average of 2059 t.

State of the juveniles (recruits)

Recruitment shows an increasing pattern, especially in the last years. The recruitment estimated for 2014 is 916101 thousand individuals, that is higher than the series average (647750 thousands, period 2007-2014).

Stock advice

The current F (1.56), computed as the geometric mean of the last three years, 2012-2014) is larger than $F_{0.1}$ (0.72), chosen as proxy of F_{MSY} and as the exploitation reference point consistent with high long term yields, which indicates that deep-water rose shrimp in GSA 18 is exploited unsustainably. Catches of deep-water rose shrimp in 2016 consistent with $F_{0.1}$ (0.72) would not exceed 938 tonnes.

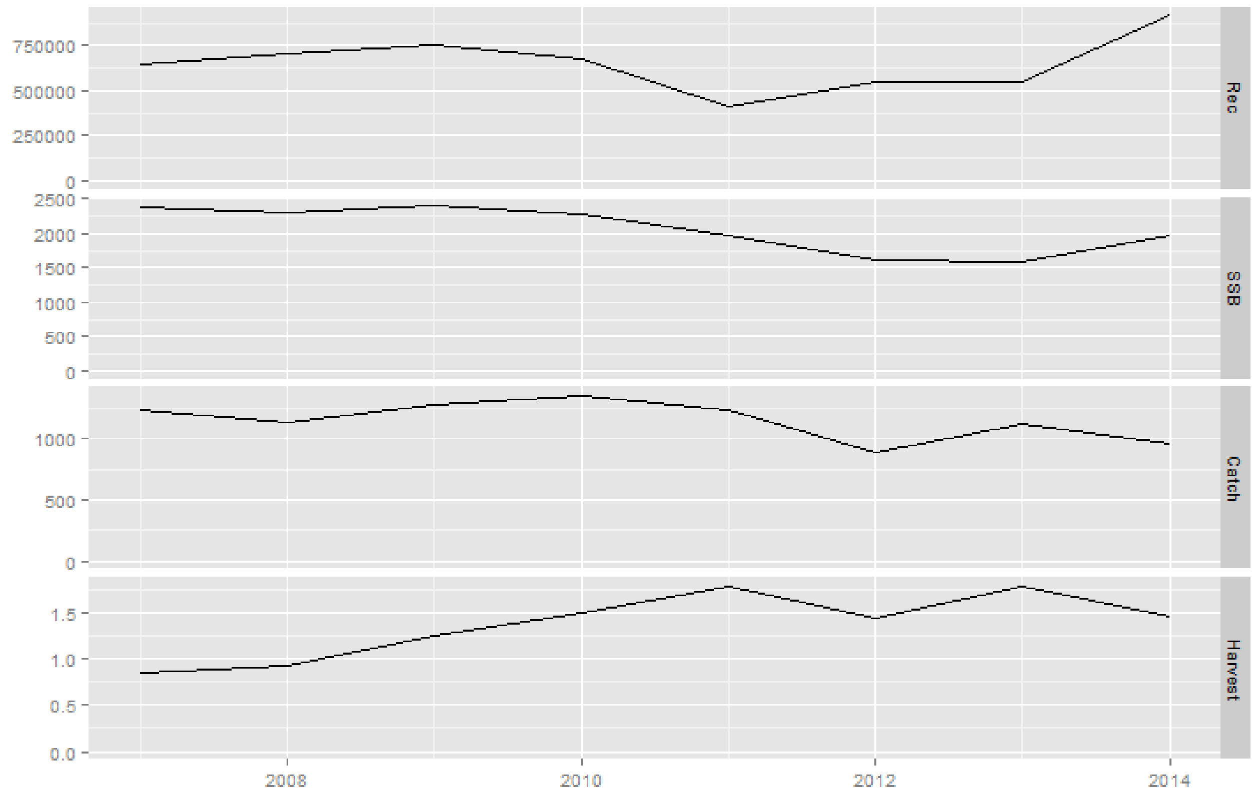


Figure 5.1.10.1.1. Deep-water rose shrimp in GSA 18. XSA summary results. SSB and catch are in tonnes, recruitment in 1000s individuals.

Basis of the assessment

The stock of deep-water rose shrimp in GSA 18 was assessed applying an Extended Survivor Analysis (XSA) method calibrated with fishery independent survey abundance indices (MEDITS in GSA 18).
Input data on landings, discards and length frequencies were taken from EU DCF data, FAO Official Statistics and national statistics for Albania and Montenegro, and from the Adriamed pilot project. Von Bertalanffy growth parameters and length-weight relationship were taken from parameters agreed and used in previous EWGs.

Catch options

The catch options for the deep-water rose shrimp in GSA 18 are summarized in Table 5.1.10.4.1.

Table 5.1.10.4.1. Deep-water rose shrimp in GSA 18. Short term forecast. Basis: F(2015) = mean(Fbar0-2 2012-2014) = 1.56; R(2015) = geometric mean of the recruitment of the last 3 years; R = 647,750 (thousands); SSB(2014) = 1,963 t, Catch (2014) = 964.5 t.

Rationale	Ffactor	Fbar	Catch 2014	Catch 2015	Catch 2016	Catch 2017	SSB 2016	SSB 2017	Change SSB 2016-2017(%)	Change Catch 2014-2016(%)
Zero catch	0.00	0.00	965	2001	0	0	2077	3528	69.9	-100.0
High long term yield (F0.1)	0.46	0.72	965	2001	938	1150	2077	2527	21.7	-2.8
Status quo	1.00	1.56	965	2001	1483	1460	2077	2041	-1.7	53.8
Different Scenarios	0.10	0.16	965	2001	268	419	2077	3225	55.3	-72.2
	0.20	0.31	965	2001	493	713	2077	2981	43.5	-48.9
	0.30	0.47	965	2001	683	923	2077	2781	33.9	-29.2
	0.40	0.62	965	2001	846	1075	2077	2617	26.0	-12.3
	0.50	0.78	965	2001	986	1186	2077	2480	19.4	2.3
	0.60	0.93	965	2001	1110	1270	2077	2365	13.9	15.0
	0.70	1.09	965	2001	1218	1335	2077	2266	9.1	26.3
	0.80	1.24	965	2001	1316	1385	2077	2181	5.0	36.4
	0.90	1.40	965	2001	1403	1426	2077	2107	1.5	45.5
	1.10	1.71	965	2001	1556	1489	2077	1982	-4.6	61.4
	1.20	1.87	965	2001	1624	1514	2077	1928	-7.2	68.4
	1.30	2.02	965	2001	1687	1536	2077	1879	-9.5	74.9
	1.40	2.18	965	2001	1746	1556	2077	1833	-11.7	81.1
	1.50	2.33	965	2001	1802	1574	2077	1791	-13.7	86.8
	1.60	2.49	965	2001	1855	1591	2077	1752	-15.6	92.3
	1.70	2.64	965	2001	1905	1606	2077	1714	-17.4	97.5
	1.80	2.80	965	2001	1953	1621	2077	1679	-19.1	102.5
	1.90	2.95	965	2001	1999	1635	2077	1646	-20.8	107.2

	2.00	3.11	965	2001	2042	1648	2077	1614	-22.3	111.7

Reference points

Table 5.1.10.5.1. Deep-water rose shrimp in GSA 18. Reference points, values and their technical basis.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$			
	F_{MSY}	0.72	$F_{0.1}$ estimated with YPR.	Present assesment
Precautionary approach	B_{lim}	1580	B_{loss}	Present assessment
	B_{pa}			
	F_{lim}			
	F_{pa}			
EU-GFCM management strategy	SSB_{lower}			
	SSB_{upper}			
	F_{lower}	0.48	Empirical relationship	Present assesment
	F_{upper}	0.89	Empirical relationship	Present assesment

Quality of the assessment

The detailed assessment can be found in section 5.2.10.

5.1.11 SUMMARY SHEET OF DEEP-WATER ROSE SHRIMP IN GSA 19

Species common name: Deep-water rose shrimp
Species scientific name: *Parapenaeus longirostris*
Geographical Sub-area(s) GSA(s): 19

Stock development over time

The SSB shows a decreasing trend, varying from 863 tons in 2008 to 286 tons in 2014. In the time series 2007-2014, SSB shows an average of 613 t. Recruitment shows a general decreasing pattern. The recruitment estimated for 2014 is 241922 thousand individuals, thus lower than the average value in the time series (299224 thousands, period 2007-2014).

Stock advice

The $F_{current}$ is equal to 1.45. This value is larger than $F_{0.1}$ (0.89), chosen as proxy of F_{MSY} and as the exploitation reference point consistent with long term yields (F_{MSY}), which indicates that the stock of deep-water pink shrimp in GSA 19 is being fished above F_{MSY}. Catches of deep-water pink shrimp in 2016 consistent with $F_{0.1}$ would not exceed 561 tonnes.

Basis of the assessment

The stock assessment of the deep pink shrimp in GSA 19 was performed applying an Extended Survivor Analysis (XSA) method calibrated with fishery independent survey abundance indices (MEDITS in GSA 19). Input data on landings, discards and length frequencies were taken from EU DCF data. Landings and discards at length data were transformed to ages using a knife edge slicing technique. Von Bertalanffy growth parameters and length-weight relationship were taken from parameters agreed and used in previous EWGs. Natural mortality (vector) was estimated using PRODBIOM.

Catch options

The catch options for the deep-water rose shrimp in GSA 19 are summarized in Table 5.1.11.4.1.

Table 5.1.11.4.1. Deep-water rose shrimp in GSA 19. Short term forecast. Basis: F(2015) = mean (Fbar 0-2 2012-2014)= 1.46; R(2015) = geometric mean of the recruitment of the last 3 years; R = 214009 (thousands); SSB(2014) = 386 t, Catch (2014)= 430 t.

Rationale	Ffactor	Fbar	Catch 2015	Catch 2016	Catch 2017	SSB 2017	Change SSB 2016-2017(%)	Change Catch 2014-2016(%)
Zero catch	0.0	0.00	570	0.0	0.0	940.7	113	-100
High long term yield (F0.1)	0.6	0.89	570	381.4	445.7	560.6	27	-11
Status quo	1.0	1.46	570	523.83	522.52	523.83	-1	22
Different Scenarios	0.2	0.29	570	158.1	236.7	775.2	76	-63
	0.3	0.44	570	222.8	311.2	710.5	61	-48
	0.4	0.58	570	280.1	367.2	654.8	48	-35
	0.5	0.73	570	331.2	409.8	606.5	38	-23
	0.6	0.87	570	377.2	443.0	564.3	28	-12

	0.7	1.02	570	418.9	469.1	527.2	20	-3
	0.8	1.16	570	456.9	490.3	494.2	12	6
	0.9	1.31	570	491.7	507.8	464.8	5	14
	1.0	1.46	570	523.8	522.5	438.4	-1	22
	1.1	1.60	570	553.5	535.3	414.6	-6	29
	1.2	1.75	570	581.1	546.5	393.1	-11	35
	1.3	1.89	570	606.8	556.6	373.5	-15	41
	1.4	2.04	570	630.9	565.8	355.6	-19	47
	1.5	2.18	570	653.4	574.4	339.2	-23	52
	1.6	2.33	570	674.7	582.4	324.2	-26	57
	1.7	2.47	570	694.7	590.0	310.4	-30	61
	1.8	2.62	570	713.5	597.2	297.6	-32	66
	1.9	2.76	570	731.4	604.1	285.9	-35	70
	2.0	2.91	570	748.3	610.8	275.1	-38	74

Reference points

Table 5.1.11.5.1. Deep-water rose shrimp in GSA 19. Reference points, values and their technical basis.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$			
	F_{MSY}	0.89	$F_{0.1}$ estimated with YPR.	Present assessment
Precautionary approach	B_{lim}	386	B_{loss}	Present assessment
	B_{pa}			
	F_{lim}			
	F_{pa}			
EU-GFCM management strategy	SSB_{lower}			
	SSB_{upper}			
	F_{lower}	0.59	Empirical relationship	Present assessment
	F_{upper}	1.21	Empirical relationship	Present assessment

Quality of the assessment

The detailed assessment can be found in section 5.2.11.

5.1.12 SUMMARY SHEET OF GIANT RED SHRIMP IN GSA 17-18-19

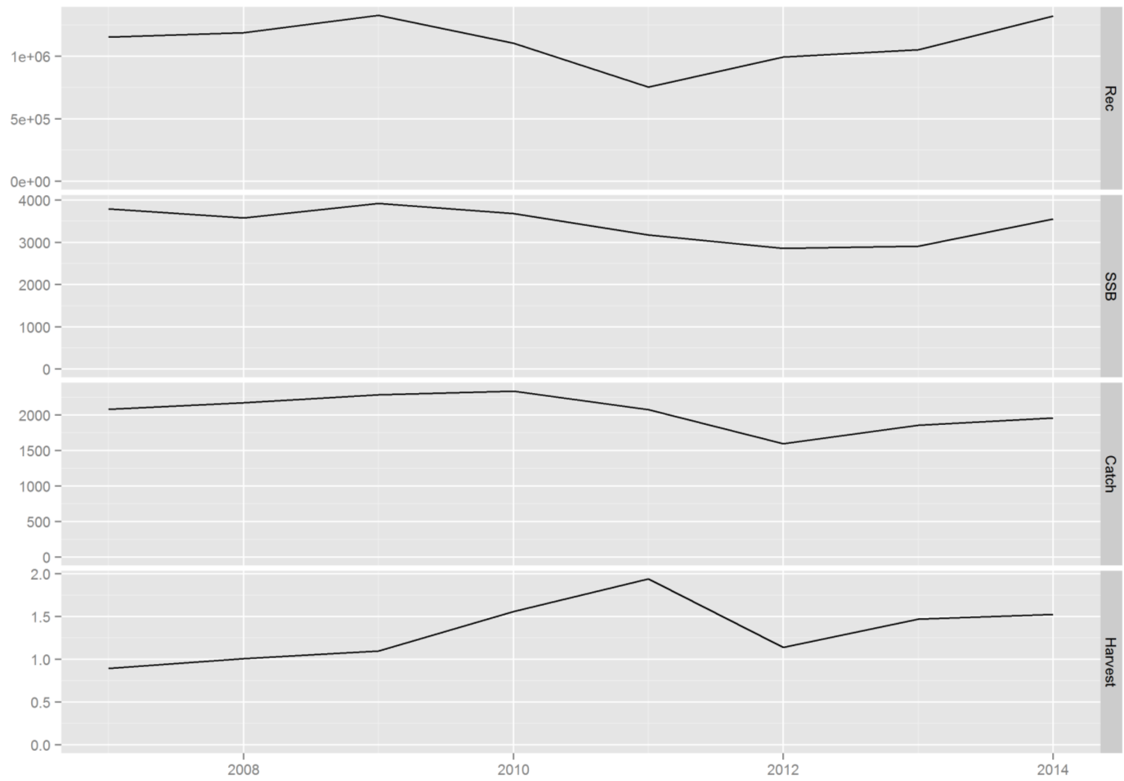
Species common name: Giant red shrimp
Species scientific name: *Aristeomorpha foliacea*
Geographical Sub-area GSA: 17-18-19

Stock development over time

State of the adult abundance and biomass
The SSB showed a slight increase over time and it estimated at about 3557 t in 2014, being the average along the time series equal to 3436.

State of the juveniles (recruits)
The recruitment estimated for 2014 is 1321770 thousand individuals, being the average along the time series equal to 1112550 thousand.

State of exploitation
The current F (1.53) is larger than F_{MSY} (0.69), which indicates that deep water rose shrimp in GSA 17-19 is is being fished above F_{MSY}.



Deep water rose shrimp in GSA 17-19. XSA summary results. SSB and catch are in tonnes, recruitment in 1000s individuals.

Stock advice
The $F_{current}$ is equal to 1.53. This value is larger than $F_{0.1}$ (0.69), chosen as proxy of F_{MSY} and as the exploitation reference point consistent with long term yields (F_{MSY}), which indicates that the stock of

deep water rose shrimp in GSA 17-19 is being fished above F_{MSY}. Deep water rose shrimp in GSA 17-19 consistent with F_{MSY} should not exceed 1588 tonnes.

Basis of the assessment

The stock of Deep water rose shrimp in GSA 17-19 was assessed applying an Extended Survivor Analysis (XSA) method calibrated with fishery independent survey abundance indices (MEDITS in GSAs 17, 18, and 19. Input data on landings, discards and length frequencies were taken from EU DCF data, FAO Official Statistics and national statistics for Croatia, Albania and Montenegro, and from the Adriamed pilot project. Von Bertalanffy growth parameters and length-weight relationship were taken from parameters agreed and used in previous EWGs.

Catch options

Catch options are summarized in the following table 5.1.12.4.1.

Table 5.1.12.4.1. Deep water rose shrimp in GSA 17-19. Short term forecast in different F scenarios. Basis: F(2015) = mean (F_{bar} 0-2 2012-2014)= 1.37; R(2015) = geometric mean of the recruitment of the last 3 years; R = 1115325 thousands; SSB(2014) = 3557 t, Catch (2014)= 1960 t.

Rationale	Ffactor	Fbar	Catch 2015	Catch 2016	Catch 2017	SSB 2016	SSB 2017	Change SSB 2016-2017(%)	Change Catch 2014-2016(%)
Zero catch	0.00	0.00	2780	0	0	3678	6140	66.96	-100.00
High long term yield (F0.1)	0.51	0.69	2780	1588	1941	3678	4451	21.03	-18.98
Status quo	1.00	1.37	2780	2477	2446	3678	3630	-1.30	26.37
Different Scenarios	0.10	0.13	2780	401	644	3678	5692	54.78	-79.52
	0.20	0.26	2780	752	1117	3678	5311	44.42	-61.63
	0.30	0.39	2780	1060	1468	3678	4985	35.56	-45.90
	0.40	0.53	2780	1333	1731	3678	4705	27.94	-31.99
	0.50	0.66	2780	1576	1931	3678	4463	21.36	-19.61
	0.60	0.79	2780	1793	2086	3678	4252	15.62	-8.52
	0.70	0.92	2780	1989	2206	3678	4067	10.60	1.47
	0.80	1.05	2780	2166	2303	3678	3904	6.17	10.53
	0.90	1.18	2780	2328	2381	3678	3759	2.23	18.79
	1.10	1.44	2780	2614	2501	3678	3513	-4.47	33.36
	1.20	1.58	2780	2741	2548	3678	3407	-7.35	39.84
	1.30	1.71	2780	2859	2590	3678	3310	-9.98	45.88
	1.40	1.84	2780	2970	2627	3678	3222	-12.40	51.53
	1.50	1.97	2780	3074	2661	3678	3140	-14.63	56.85
	1.60	2.10	2780	3173	2692	3678	3063	-16.70	61.87
	1.70	2.23	2780	3266	2721	3678	2992	-18.63	66.62
	1.80	2.36	2780	3354	2748	3678	2926	-20.45	71.13

	1.90	2.50	2780	3438	2773	3678	2863	-22.15	75.43
	2.00	2.63	2780	3519	2798	3678	2804	-23.76	79.54

Reference points

Table 5.1.12.5.1. Deep water rose shrimp in GSA 17-19. Reference points, values and their technical basis.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$			
	F_{MSY}	0.69	$F_{0.1}$ estimated with YPR.	Present assessment
Precautionary approach	B_{lim}	2863	B_{loss}	Present assessment
	B_{pa}			
	F_{lim}			
	F_{pa}			
EU-GFCM management strategy	SSB_{lower}			
	SSB_{upper}			
	F_{lower}	0.46	Empirical relationship	Present assessment
	F_{upper}	0.94	Empirical relationship	Present assessment

Quality of the assessment

The detailed assessment can be found in section 5.2.12.

5.1.13 SUMMARY SHEET OF GIANT RED SHRIMP IN GSA 18

Species common name: Giant red shrimp
Species scientific name: *Aristaeomorpha foliacea*
Geographical Sub-area(s) GSA(s): 18

5.1.13.1 Stock development over time

The assessment was carried out using an XSA model. The assessment was not accepted and thus short term forecast and advice were not provided. Nevertheless, the following sections describes the results as obtained by the XSA model.

According to the XSA results, SSB estimates fluctuated between a minimum of 150 tonnes in 2008 to a maximum of 503 tonnes in 2013; over the entire time series SSB showed an increasing pattern.

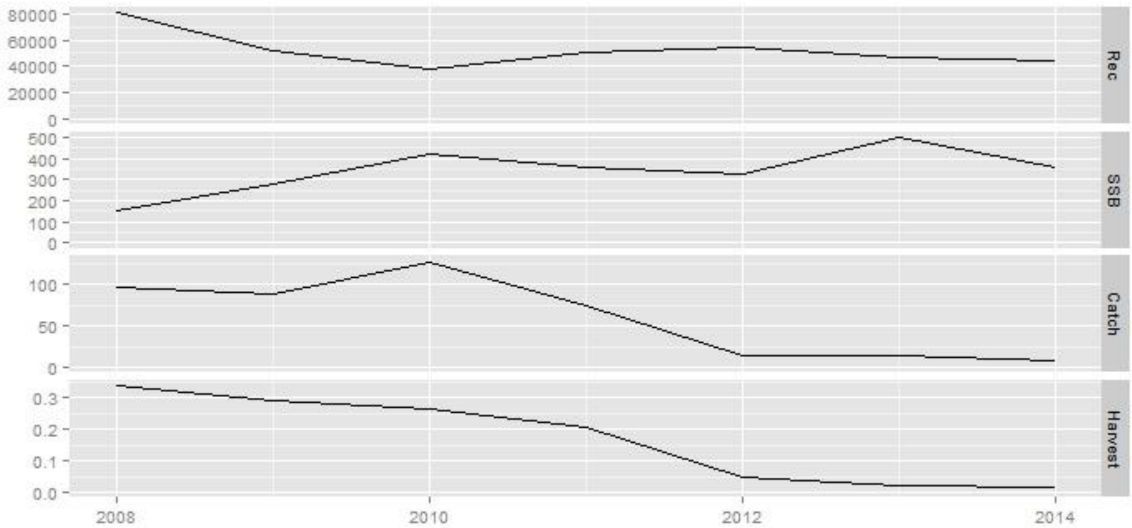


Figure 5.1.13.1.1. Giant red shrimp in GSA 18. XSA summary results. SSB and catch are in tons, recruitment in thousands of individuals.

From XSA results, recruitment decreased from a maximum of 81 million in 2009 to 44 million in 2014. Survey data similarly recorded highest levels of recruitment in 2009, and lowest levels in 2014.

The results of the XSA assessment showed a steep decline catches and in fishing mortality from 2008 to 2014, with F in 2014 = 0.02. The reason for such a decline is however most likely due to the fact that the giant red shrimp population in GSA 18 is in fact part of a larger stock distributed in GSA 18 and 19 (see section 5.2.13 for details on geographical distribution patterns); i.e. giant red shrimp in GSA 18 cannot be considered a separate stock. A joint assessment combining data from GSA 18 and 19 was thus considered more appropriate for this species.

5.1.13.2 Stock advice

No stock advice is given for giant red shrimp in GSA 18 since an independent assessment of GSA 18 was not considered to be a suitable approach.

5.1.13.3 Basis of the assessment

An XSA analysis was performed using 2008-2014 DCF data using catch at age data provided and tuned with fishery independent abundance indices (MEDITS survey). A vector of natural mortality was obtained applying PRODBIOM. In addition, Yield per Recruit (YPR) analysis was performed for the estimation of $F_{0.1}$ (i.e. proxy of FMSY).

5.1.13.4 Catch options

No advice on catch options is given for giant red shrimp in GSA 18 since an independent assessment of GSA 18 was not considered to be a suitable approach.

5.1.13.5 Reference points

The separate assessment for GSA 18 was not accepted since giant red shrimp in GSA 18 cannot be considered a separate stock. As a consequence no reference points are reported.

5.1.13.6 Quality of the assessment

Giant red shrimp in GSA 18 cannot be considered a separate stock. A joint assessment combining data from GSA 18 and 19 was thus considered more appropriate for this species. See section 5.2.13 for more details regarding giant red shrimp in GSA 18, and section 5.2.15 for a joint assessment of giant red shrimp in GSA 18 and 19.

Reference points

Table 5.1.13.6.1. Giant red shrimp in GSA 18. Reference points, values and their technical basis.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$			
	F_{MSY}			
Precautionary approach	B_{lim}			
	B_{pa}			
	F_{lim}			
	F_{pa}			
EU-GFCM management strategy	SSB_{lower}			
	SSB_{upper}			
	F_{lower}			
	F_{upper}			

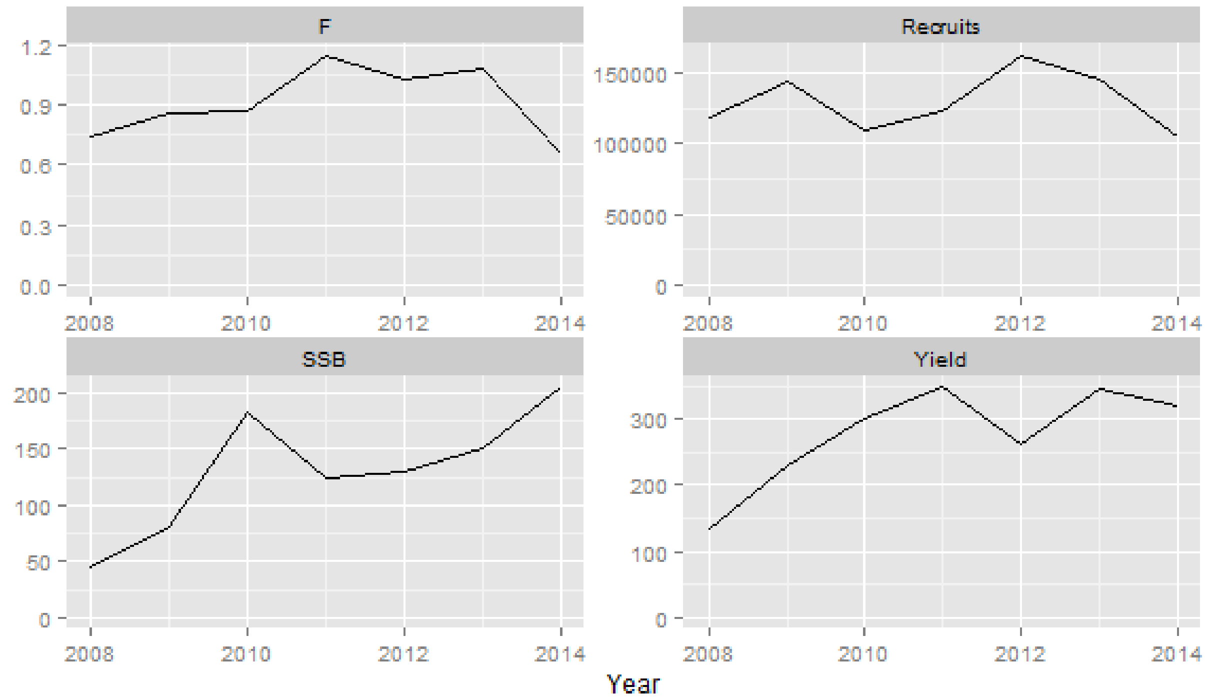
The detailed assessment can be found in section 5.2.13.

5.1.14 SUMMARY SHEET OF GIANT RED SHRIMP IN GSA 19

Species common name: Giant red shrimp
Species scientific name: *Aristaeomorpha foliacea*
Geographical Sub-area(s) GSA(s): 19

Stock development over time

SSB showed an increasing trend in the analysed period, varying from 44.4 tons in 2008 to 205 tons in 2014.
Recruitment is characterised by a fluctuating trend, varying from a minimum of 105 millions in 2014 to 162 millions in 2012.
F_{curr} showed an evident increasing trend in the period 2008-2010. High values were found from 2011 to 2013, while in 2014 a decrease was observed. According to the F estimates obtained using landing and discard data with XSA, F_{curr} (0.90), estimated as geometric mean of the last three years (2012-2014), was above the estimated reference value of $F_{0.1}$ (0.29) chosen as proxy of F_{MSY} and as the exploitation reference point consistent with high long term yields.



Giant red shrimp in GSA 19. XSA summary results. SSB and catch are in tons, recruitment in 1000s individuals.

Stock advice

The $F_{current}$ is equal to 0.90. This value is larger than $F_{0.1}$ (0.29), chosen as proxy of F_{MSY} and as the exploitation reference point consistent with long term yields (F_{MSY}), which indicates that the stock of giant red shrimp in GSA 19 is being fished above F_{MSY}. Catches of the giant red shrimp in 2016 consistent with $F_{0.1}$ (0.29) would not exceed 141 tons.

Basis of the assessment

The stock assessment of the giant red shrimp in GSA 19 was performed applying an Extended Survivor Analysis (XSA) method calibrated with fishery independent survey abundance indices (MEDITS). In addition, a yield-per-recruit (Y/R) analysis was carried out. Both methods were performed from the size composition of landings and discards, transforming length data to ages using slicing technique.

Input data landings, discards and length frequencies were taken from DCF. Von Bertalanffy growth parameters and length-weight relationship were taken from parameters estimated for the giant red shrimp in GSA 19. Natural mortality (vector) was estimated using PRODBIOM.

Catch options

The catch options for the giant red shrimp stock in GSA 19 are summarised in Table 5.1.14.4.1.

Table 5.1.14.4.1. Giant red shrimp in GSA 19. Short term forecast. Basis: F(2015) = mean(Fbar 0-3 2012-2014)= 0.901; R(2015) = geometric mean of the recruitment of the last 3 years; R = 135399 (thousands); Catch (2014)= 320 t.

Rationale	Ffactor	Fbar	Catch 2016	Catch 2017	SSB 2017	Change SSB 2016-2017(%)	Change Catch 2014-2016(%)
Zero catch	0	0	0	0	558.2	94.9	-100
High long term yield F(0.1)	0.33	0.29	140.7	207.8	355.1	50.2	-56.0
Status quo	1	0.90	324.5	346.6	168.2	2.4	1.4
Different scenarios	0.1	0.09	48.6	83.3	482.6	79.0	-84.8
	0.2	0.18	92.2	147.5	419.6	65.1	-71.2
	0.3	0.27	131.4	197.2	366.9	53.0	-58.9
	0.4	0.36	166.9	235.9	322.7	42.4	-47.8
	0.5	0.45	199.2	266.1	285.4	33.2	-37.8
	0.6	0.54	228.6	290.0	253.9	25.2	-28.6
	0.7	0.63	255.5	308.9	227.1	18.3	-20.2
	0.8	0.72	280.3	324.1	204.4	12.2	-12.4
	0.9	0.81	303.2	336.5	184.9	6.9	-5.2
	1.1	0.99	344.2	355.0	153.7	-1.6	7.6
	1.2	1.08	362.6	362.2	141.2	-5.0	13.3
	1.3	1.17	379.9	368.3	130.4	-8.0	18.7
	1.4	1.26	396.1	373.6	120.9	-10.5	23.8
	1.5	1.35	411.3	378.3	112.6	-12.7	28.5
	1.6	1.44	425.6	382.5	105.1	-14.6	33.0
	1.7	1.53	439.1	386.3	98.6	-16.1	37.2
	1.8	1.62	451.9	389.8	92.8	-17.5	41.2
	1.9	1.71	464.1	393.1	87.6	-18.6	45.0
	2.0	1.80	475.6	396.1	82.9	-19.6	48.6

Reference points

Table 5.1.14.5.1. Giant red shrimp in GSA 19. Reference points, values and their technical basis.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$			
	F_{MSY}	0.29	$F_{0.1}$ estimated with YpR	Present assessment
Precautionary approach	B_{lim}	44.4	B_{loss}	Present assessment
	B_{pa}			
	F_{lim}			
	F_{pa}			
EU-GFCM management strategy	SSB_{lower}			
	SSB_{upper}			
	F_{lower}	0.19	Empirical relationship	Present assessment
	F_{upper}	0.40	Empirical relationship	Present assessment

Quality of the assessment

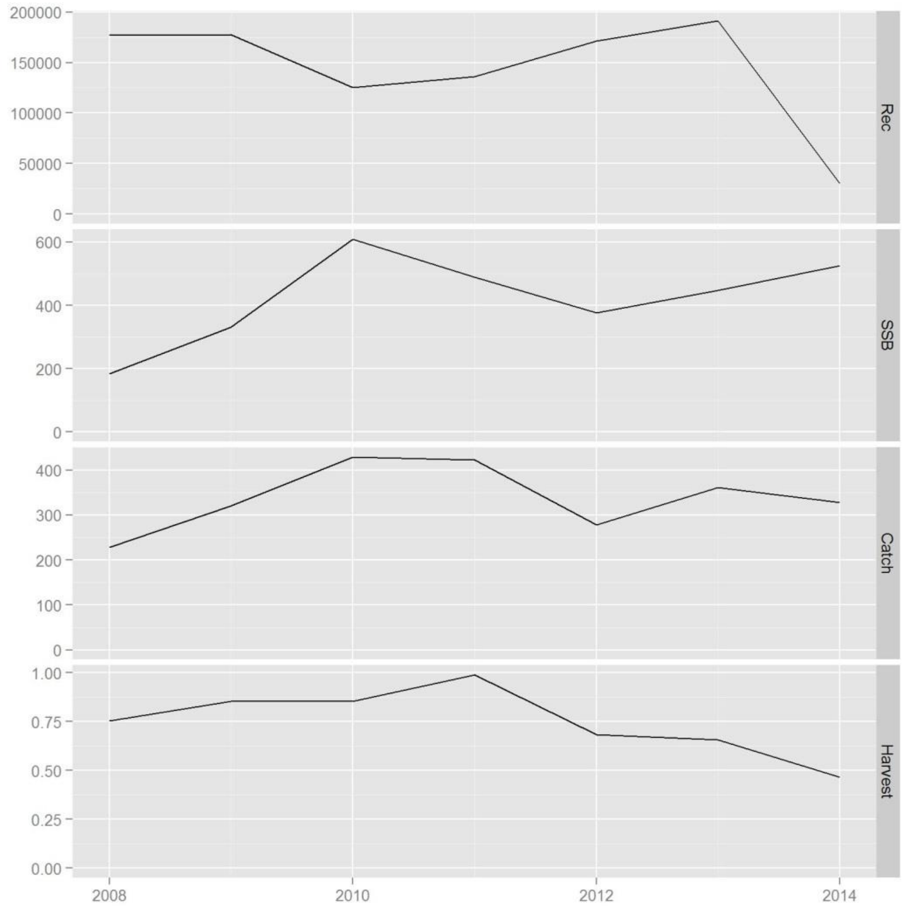
The detailed assessment can be found in section 5.2.14.

5.1.15 SUMMARY SHEET OF GIANT RED SHRIMP IN GSA 18-19

Species common name: Giant red shrimp
Species scientific name: *Aristaeomorpha foliacea*
Geographical Sub-area(s) GSA(s): 18-19

Stock development over time

The SSB showed a slight increase in the last two years and it estimated at about 525 t in 2014, being the average along the time series equal to 423.
The recruitment estimated for 2014 is very low, about 30222 thousand individuals, being the average along the time series equal to 144201 thousand.
The current F (0.46) is larger than F_{MSY} (0.42), which indicates that Giant red shrimp in GSA 18-19 is is being fished above F_{MSY}.



Giant red shrimp in GSA 18-19. XSA summary results. SSB and catch are in tonnes, recruitment in 1000s individuals.

Stock advice

The current F (0.46) is larger than $F_{0.1}$ (0.42), chosen as proxy of F_{MSY} and as the exploitation reference point consistent with high long term yields, which indicates that giant red shrimp in GSA 18-19 is being fished above F_{MSY}. Catches of giant red shrimp in 2016 consistent with F_{MSY} should not exceed 153 tonnes.

Basis of the assessment

The stock of Giant red shrimp in GSA 18-19 was assessed applying an Extended Survivor Analysis (XSA) method calibrated with fishery independent survey abundance indices (MEDITS in GSAs 18, and 19). Input data on landings, discards and length frequencies were taken from EU DCF data.

Catch options

Catch options are summarized in the following table 5.1.15.4.1.

Table 5.1.15.4.1. Giant red shrimp in GSA 18-19. Short term forecast in different F scenarios. Basis: F(2015) = mean (F_{bar} 0-3 2012-2014)= 0.59; R(2015) = geometric mean of the recruitment of the last 3 years; R = 99708 thousands; SSB(2014) =525 t, Catch (2014)= 328 t.

Rationale	Ffactor	Fbar	Catch 2015	Catch 2016	Catch 2017	SSB 2016	SSB 2017	Change SSB 2016-2017(%)	Change Catch 2014-2016(%)
Zero catch	0.00	0.00	298.07	0.00	0.00	316.37	547.48	73.05	-100.00
High long term yield (F0.1)	0.71	0.42	298.07	152.84	215.60	316.37	411.18	29.97	-53.42
Status quo	1.00	0.59	298.07	201.16	255.17	316.37	370.45	17.09	-38.69
Different Scenarios	0.10	0.06	298.07	25.01	46.44	316.37	524.46	65.77	-92.38
	0.20	0.12	298.07	48.71	86.05	316.37	502.90	58.96	-85.16
	0.30	0.18	298.07	71.19	119.89	316.37	482.67	52.56	-78.30
	0.40	0.24	298.07	92.54	148.87	316.37	463.67	46.56	-71.80
	0.50	0.30	298.07	112.85	173.73	316.37	445.79	40.91	-65.61
	0.60	0.35	298.07	132.19	195.11	316.37	428.95	35.58	-59.71
	0.70	0.41	298.07	150.64	213.53	316.37	413.06	30.56	-54.09
	0.80	0.47	298.07	168.24	229.44	316.37	398.06	25.82	-48.72
	0.90	0.53	298.07	185.07	243.21	316.37	383.88	21.34	-43.60
	1.10	0.65	298.07	216.57	265.57	316.37	357.73	13.07	-34.00
	1.20	0.71	298.07	231.33	274.64	316.37	345.67	9.26	-29.50
	1.30	0.77	298.07	245.49	282.58	316.37	334.22	5.64	-25.18
	1.40	0.83	298.07	259.08	289.54	316.37	323.35	2.21	-21.04

	1.50	0.89	298.07	272.13	295.66	316.37	313.02	-1.06	-17.06
	1.60	0.95	298.07	284.68	301.05	316.37	303.18	-4.17	-13.24
	1.70	1.01	298.07	296.75	305.82	316.37	293.83	-7.13	-9.56
	1.80	1.06	298.07	308.37	310.05	316.37	284.91	-9.94	-6.02
	1.90	1.12	298.07	319.57	313.81	316.37	276.41	-12.63	-2.61
	2.00	1.18	298.07	330.35	317.17	316.37	268.31	-15.19	0.68

Reference points

Table 5.1.15.5.1. Giant red shrimp in GSA 18-19. Reference points, values and their technical basis.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$			
	F_{MSY}	0.42	$F_{0.1}$ estimated with YPR.	Present assessment
Precautionary approach	B_{lim}	184	B_{loss}	Present assessment
	B_{pa}			
	F_{lim}			
	F_{pa}			
EU-GFCM management strategy	SSB_{lower}			
	SSB_{upper}			
	F_{lower}	0.28	Empirical relationship	Present assessment
	F_{upper}	0.57	Empirical relationship	Present assessment

Quality of the assessment

The detailed assessment can be found in section 5.2.15.

5.2 DETAILED STOCK ASSESSMENTS

5.2.1 STOCK ASSESSMENT OF HAKE IN GSA 17-18

Stock Identification

The stock of European hake was assumed within the boundaries of the whole Adriatic Sea (GSA 17-18) (Fig. 5.2.1.1.1), as suggested by the genetic results of the MAREA StockMed project that shows a common sub-population of hake throughout the Adriatic Sea. However, project identifies two distinct stock units in the Adriatic Sea, uncorrelated with the GSA units (Fiorentino et al., 2014).

The species depth distribution ranges between several meters in the coastal area down to 800 m in the South Adriatic Pit (Kirinčić and Lepetić, 1955; Ungaro et al., 1993), though it is most abundant at depths between 100 and 200 m, where the catches are mainly composed of juveniles (Bello et al., 1986; Vrgoč, 2000). In the northern and central part of the Adriatic Sea adults are mainly caught at depths of 100 to 150 m (Vrgoč et al., 2004), whereas in the south Adriatic largest individuals are caught in waters deeper than 200 m and medium-sized fish appear in waters not deeper than 100 m (Ungaro et al., 1993).

The geographical distribution pattern of European hake has been studied in the area using trawl-survey data and geostatistical methods. This species presents the greatest abundance in the central Adriatic Sea in water deeper than 100 meters, whereas the greatest biomass is found in the eastern part of the Adriatic Sea, where the biggest sizes individuals are concentrated (Piccinetti et al., 2012). Nursery areas are located in the central Adriatic Sea, off Gargano promontory and in the southern part of Albanian coasts (Frattini and Paolini, 1995; Lembo et al., 2000; Carlucci et al., 2009).

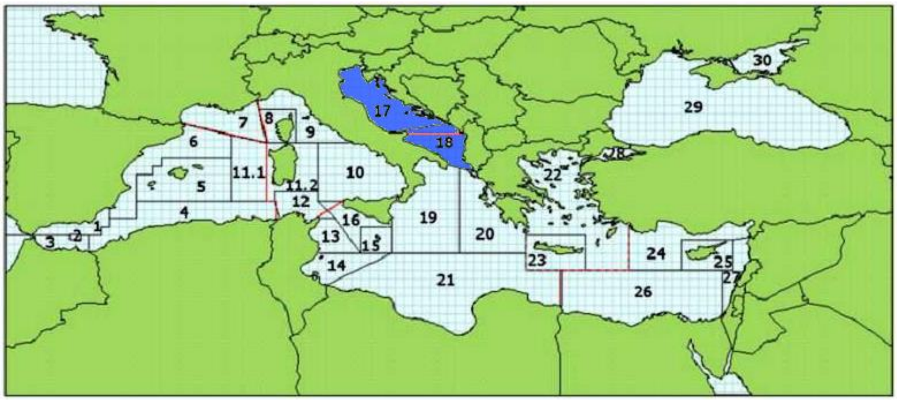


Figure 5.2.1.1.1. Geographical location of GSA 17 and 18.

Growth

European hake can reach a total length of up to 107 cm (Grubišić, 1959). However, the most common total length recorded in trawl catches ranges between 10 and 60 cm. It is a long-lived species that can reach over 20 years of age, but the exploited stock in the Adriatic Sea is mainly composed of young individuals, from age 0 to age 3.

Females attain larger size than males whose growth slows down after maturation at the age of three or four years. Consequently, the proportion of males in the population is higher in the lower length classes, whereas females are more abundant at greater lengths (Vrgoć, 2000).

According to previous stock assessments, the growth parameters used for this evaluation reflect the fast growth scenario and they are reported in Table 5.2.1.2.1.

Table 5.2.1.2.1. Growth parameters and length-weight relationship for European hake used in the assessment.

L_{inf}	K	t_0	a	b
104 cm	0.2 years^{-1}	-0.01 years	0.0043	3.2

Maturity

M. merluccius is a batch spawner and, in the Adriatic Sea, spawns with varying intensities throughout the year. Peaks of spawning occur in summer and winter (Karlovac, 1965; Županović and Jardas, 1989; Jukić and Piccinetti, 1981; Ungaro *et al.*, 1993). Females spawn usually four or five times without ovarian rest. Recent estimates of batch fecundity (Donnaloia, 2009) in Adriatic Sea reported higher values in comparison to the fecundity reported by Murua et al. (2006) for the Atlantic Sea and Recasens et al. (2008) for the Northern Tyrrhenian Sea. Females in pre-spawning stage can contain more than 400,000 oocytes at 70 cm in length (Sarano, 1986). The earliest spawning occurs in wintertime in the deeper water (up to 200 m) of the Pomo/Jabuka Pit; as the season progresses into the spring-summer period, spawning occurs in more shallow water. Karlovac (1965) recorded young hake larvae from October to June, the highest numbers were recorded in January and February. Larvae and post-larvae were mainly distributed between 40 and 200 m; the highest number of individuals was caught mainly between 50 and 100 m. Recruitment peaks in the winter and late spring (Ungaro et al., 1993; Donnaloia, 2009). Table 5.2.1.3.1 reports the proportion of mature fish by age used in the assessessment.

Table 5.2.1.3.1. Propotion mature at age for European hake in GSA 17-18.

Age	Proportion mature
0	0.00
1	0.12
2	0.92
3	1.00
4	1.00
5+	1.00

Natural mortality

Natural mortality was estimated using PRODBIOM (Abella et al., 1997; Tab. 5.2.1.4.1).

Table 5.2.1.4.1. Natural mortality vector for European hake in GSA 17-18 estimated using PRODBIOM.

Age	M
0	1.16
1	0.53
2	0.40
3	0.35
4	0.32
5+	0.32

Fisheries

5.2.1.1.1 General description of the fisheries

European hake is one of the most important demersal fisheries resources in the Adriatic Sea, it accounts for the highest landings quantity among demersal species. Fishing grounds mostly correspond to the distribution of the stock.

5.2.1.1.2 Management regulations applicable in 2015

Management regulations in Italy, Slovenia and Croatia are determined by the EU regulations (mainly EC regulation 1967/2006):

- Minimum landing sizes: 20 cm TL for European hake
- Fishing closure for trawling: 30-45 days in summer
- Codend mesh size of trawl nets: 40 mm (stretched, diamond meshes) till 30/05/2010. From 1/6/2010 the existing nets have been replaced with a cod end with 40 mm (stretched) square meshes or a cod end with 50 mm (stretched) diamond meshes
- Towed gears are not allowed within three nautical miles from the coast or at depths less than 50 m when this depth is reached at a distance less than 3 miles from the coast
- Fishing closure of the Pomo Pit area (Fig. 5.2.1.5.2.1) from the 26th of July 2015 to the 26th of July 2016

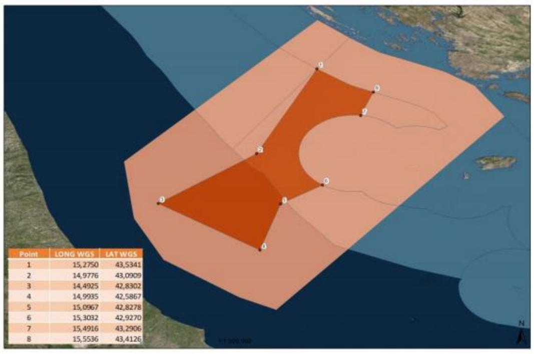


Figure 5.2.1.5.2.1. Map of the Pomo Pit area close to the fishing activity (orange polygon).

For Croatia only other regulations are expected:

- Bottom trawl fisheries is closed one and half nautical mile from the coast and island in inner sea, 2 nautical mile around island on the open sea, and 3 nautical mile about several island in the central Adriatic. Bottom trawl fishery is closed also in the majority of channel area and bays. About 1/3 of the territorial waters is closed for bottom trawl fisheries over whole year and additionally 10% is closed from 100-300 days per years
- For vessel smaller than 15 meters, according derogation in sea deeper than 50 meters bottom trawl fisheries is forbidden till 1 nautical mile of the coast
- before the EU regulations, minimum mesh size on the bottom trawl net was 20 mm ("knot to knot") in the open sea, and 24 mm ("knot to knot") in the inner sea.

5.2.1.1.3 Catches

Catches of European hake are realized mainly by bottom trawl fisheries. Hereunder the representation of length composition in catches is reported (Fig. 5.2.1.5.3.1), whereas details of landings and discards are reported in the following sections.

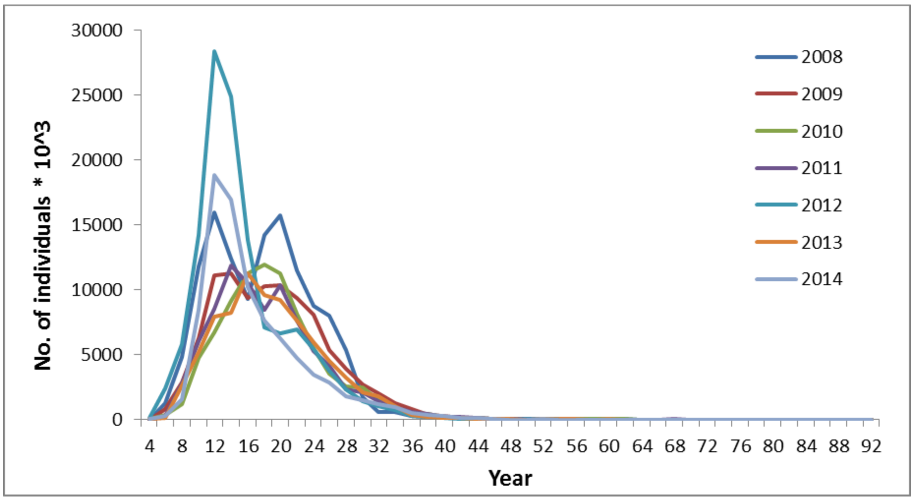


Figure 5.2.1.5.3.1 European hake in GSA 17 and 18. Length Frequency Distribution of catches from 2008 to 2014.

5.2.1.1.4 Landings

On the basis of DCR data, Italy accounts for the highest landings, followed by Croatia and Slovenia (Table 5.2.1.5.4.1). The main gear fishing hake is represented by bottom trawls: Italian bottom trawls account for around the 60% of the total landings, whereas Croatian bottom trawls represent the 30% of total landings. Longlines are the second most important gear exploiting hake: Italian longliners account for around the 5% of the total landings, whereas Croatian longliners represent the 1% of total landings. Passive gears (gillnets (GNS) and trammel net (GTR)) and beam trawls (TBB) represent a small percentage of landings (Table 5.2.1.5.4.2).

Table 5.2.1.5.4.1. European hake in GSA 17 and 18. Landings (in tonnes) from 2004 to 2014.

	ITA	HRV	SVN	Total
2004	3204			3204
2005	3785		2	3787
2006	9723		3	9726

2007	7589		6	7596
2008	7285		1	7286
2009	6655		2	6656
2010	5884		0	5884
2011	5321		0	5322
2012	4897		0	4898
2013	4759	3096	1	7856
2014	3682	1673	1	5356

Table 5.2.1.5.4.2. European hake in GSA 17 and 18. Landings (in tonnes) by year, country and fishing gear.

	HRV			**ITA**				**SLO**	**TOTAL**			
	GNS-GTR	**LLS**	**OTB**	**GNS-GTR**	**LLS**	**OTB**	**TBB**	**OTB**	**GNS-GTR**	**LLS**	**OTB**	**TBB**
2004				40	233	2932				233	2932	0
2005				56	454	3275		2	56	454	3278	0
2006				56	838	8592	237	3	56	838	8596	237
2007				37	620	6932		6	37	620	6938	0
2008				57	551	6677		1	57	551	6678	0
2009				27	534	6094		2	27	534	6095	0
2010				19	601	5263		0	19	601	5263	0
2011				18	519	4772	12	0	18	519	4772	12
2012				20	566	4297	15	0	20	566	4297	15
2013	43		3053	0	188	4571		1	43	188	7625	0
2014	58	61	1554	0	279	3373	30	1	59	340	4928	30

5.2.1.1.5 Discards

On the basis of DCR data, discard is reported from 2009 for Italy, from 2013 for Croatia and no discard is observed for Slovenia (Table 5.2.1.5.5.1). Bottom trawl is the principal gear producing discards and the highest values are reported for Croatia (Table 5.2.1.5.5.2).

Table 5.2.1.5.5.1. European hake in GSA 17 and 18. Discards (in tonnes).

	HRV	**ITA**	**SVN**	**Total**
2009		152		152
2010		78		78
2011		109		109
2012		184		184
2013	573	18		592
2014	675	58		733

Table 5.2.1.5.5.2. European hake in GSA 17 and 18. Discards (in tonnes) by year, country and fishing gear.

Country	**HRV**	**ITA**	**SVN**	

	OTB	LLS	OTB	Total	TOTAL
2009		0	152		152
2010		0	78		78
2011		0	109		109
2012		0.32	183		184
2013	573	0	18		592
2014	675	0.95	57		733

5.2.1.1.6 Fishing effort

In the Adriatic Sea hake is primarily a target species for bottom trawlers (OTB) and to a lesser extent for longliners (LLS), set gillnets (GNS), trammel nets (GTR) and beam trawls (TBB). The activity of longliners, set gillnets, trammel nets and beam trawls is negligible compared to the bottom trawl fishery activity. Table 5.2.1.5.6.1 shows the fishing effort, GT per days and kW per days**,** by country and overall, whereas table 5.2.1.5.6.2 reports the GT per days at sea by gear and country and table 5.2.1.5.6.3 summarizes GT per days at sea by year and fishing gear. Fishing effort in kW per days are grouped by gear and country in table 5.2.1.5.6.4 and only by gear in table 5.2.1.5.6.5.

Table 5.2.1.5.6.1. European hake in GSA 17 and 18. Fishing effort, GT per days and kW per Days, by country.

	GT per Days				kW per Days			
	HRV	ITA	SVN	TOTAL	HRV	ITA	SVN	TOTAL
2002						55699696		55699696
2003						50666122		50666122
2004		9377181		9377181		55262319		55262319
2005		8890751	14969	8905720		51318605	206961	51525566
2006		8317081	18264	8335345		47687704	235887	47923591
2007		7890524	28978	7919502		43722527	360273	44082800
2008		7400855	30407	7431262		42160222	398220	42558442
2009		7726259	29979	7756238		44441468	406704	44848172
2010		7307524	31398	7338922		41145744	439989	41585733
2011		6565416	32281	6597697		38790118	454730	39244848
2012	3985024	6082169	31119	10098312	24224608	35821581	468958	60515147
2013	5658020	5649532	32461	11340013	35112188	31815002	474511	67401700
2014	5620420	5582848	26065	11229333	34542722	31383484	407939	66334145

Table 5.2.1.5.6.2. European hake in GSA 17 and 18. Fishing effort, GT per days, by country and fishing gear.

Country	HRV			ITA					SVN
Year	GNS	LLS	OTB	GNS	GTR	LLS	OTB	TBB	OTB
2004				313229	161295	63792	7835736	1003129	0
2005				357318	149970	77906	7519968	785589	9155

2006				333456	111072	77793	6741848	1052912	12291
2007				227006	146961	69177	6351016	1096364	17413
2008				186560	140756	107911	6121887	843741	18858
2009				253065	146020	64941	6217030	1045203	18191
2010				247279	146123	87474	5905490	921158	18235
2011				281318	159577	76512	5382854	665155	17782
2012	237825	57100	3482698	297775	138850	73446	4799392	772706	15063
2013	370418	43755	4946529	246659	72230	32817	4640270	657556	11960
2014	352949	41420	4955927	255055	96645	38728	4299825	892595	9372

Table 5.2.1.5.6.3. European hake in GSA 17 and 18. Fishing effort, GT per days, by fishing gear.

Country	**ALL**				
Year	**GNS**	**GTR**	**LLS**	**OTB**	**TBB**
2004	313229	161295	63792	7835736	1003129
2005	357318	149970	77906	7529123	785589
2006	333456	111072	77793	6754139	1052912
2007	227006	146961	69177	6368429	1096364
2008	186560	140756	107911	6140745	843741
2009	253065	146020	64941	6235221	1045203
2010	247279	146123	87474	5923725	921158
2011	281318	159577	76512	5400636	665155
2012	535600	138850	130546	8297153	772706
2013	617077	72230	76572	9598759	657556
2014	608004	96645	80148	9265124	892595

Table 5.2.1.5.6.4. European hake in GSA 17 and 18. Fishing effort, in kW per days, by country and fishing gear.

Country	**HRV**			**ITA**					**SVN**
Year	**GNS**	**LLS**	**OTB**	**GNS**	**GTR**	**LLS**	**OTB**	**TBB**	**OTB**
2002				11019580			44680116		
2003				8648936			42017186		
2004				5933656	2223885	596928	42275313	4232537	
2005				7016405	1790725	1054068	37644492	3812915	112663
2006				6101313	1225882	772851	34641421	4946237	143526
2007				3819332	1787867	634243	32249251	5231834	183978
2008				3346053	1914906	1260704	31502213	4136346	198181
2009				4485963	1916843	884150	32768358	4386154	200880
2010				3966780	2146768	1263867	29950838	3817491	207862
2011				5094267	2286656	922942	27901536	2584717	188621
2012	3737006	1165917	15985566	5709787	2046945	967941	23842721	3254187	153646
2013	5734066	903708	23186904	3752111	1714453	452813	23125950	2769675	113694

2014	5549831	812941	23372461	4072122	1112850	297350	22171347	3729815	99847

Table 5.2.1.5.6.5. European hake in GSA 17 and 18. Fishing effort, in kW per days, by fishing gear.

Country	ALL				
Year	**GNS**	**GTR**	**LLS**	**OTB**	**TBB**
2002	11019580	0	0	44680116	0
2003	8648936	0	0	42017186	0
2004	5933656	2223885	596928	42275313	4232537
2005	7016405	1790725	1054068	37757155	3812915
2006	6101313	1225882	772851	34784947	4946237
2007	3819332	1787867	634243	32433229	5231834
2008	3346053	1914906	1260704	31700394	4136346
2009	4485963	1916843	884150	32969238	4386154
2010	3966780	2146768	1263867	30158700	3817491
2011	5094267	2286656	922942	28090157	2584717
2012	9446793	2046945	2133858	39981933	3254187
2013	9486177	1714453	1356521	46426547	2769675
2014	9621953	1112850	1110291	45643655	3729815

Scientific surveys

5.2.1.1.7 Survey #1 (MEDITS)

5.2.1.1.7.1 Methods

The MEDITS (MEDiterranean International Trawl Survey) survey is an extensive trawls survey occurring in all European countries and included in the Data Collection Framework. According to the MEDITS protocol (Bertrand et al., 2002), it takes places every year during springtime following a random stratified sampling by depth (5 strata: 10-50 m, 50-100 m, 100-200 m, 200-500m and over 500 m). The number of hauls in each stratum is proportional to the surface of the stratum and their positions were randomly selected and maintain fixed throughout the time. Same sampling gear (called GOC73), characterized by a 20 mm stretched mesh size cod-end, is used throughout GSAs and years. Details on its characteristics and performance are reported in Dremière and Fiorentini (1996).
The abundance and biomass indices by GSA were calculated through stratified means.

5.2.1.1.7.2 Geographical distribution

European hake is distributed throughout the Adriatic Sea, with the exception of a small area northern of the Po river (Fig. 5.2.1.6.1.2.1). The greatest abundance of this species is found in the central Adriatic Sea, in water deeper than 100 meters, where population is manly composed of juveniles (Fig. 5.2.1.6.1.2.2).
Within the MEDISEH project (DG MARE Specific Contract SI2.600741, call for tenders MARE/2009/05), MEDITS data were analysed to locate nursery and spawning area. Positions of nursery area in GSA 17 were identified in the central Adriatic Sea, around the Pomo/Jabuka Pits (Fig.

5.2.1.6.1.2.2), whereas spawning grounds were located in the western part of the Adriatic Sea (Fig. 5.2.1.6.1.2.3). In GSA 18 it was possible to identify only the positions of nursery areas, localised off-shore the Gargano Promontory and in the most southern part of the GSA both eastward (off-shore Vlora) and westward, mainly between 100 and 200 m depth, along the border of Otranto Channel and off-shore Dürres (Fig. 5.2.1.6.1.2.4).

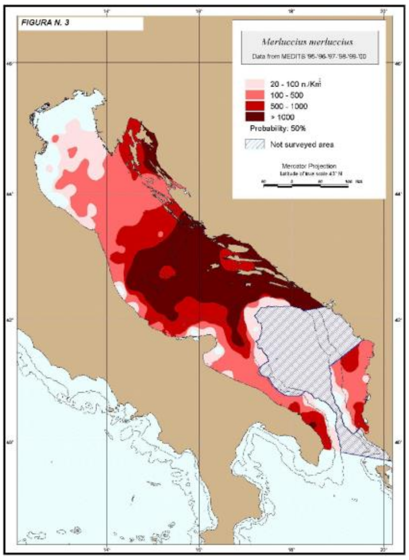


Figure 5.2.1.6.1.2.1. European hake in GSA 17 and 18. Distribution map from MEDITS survey (Sabatella and Piccinetti, 2005).

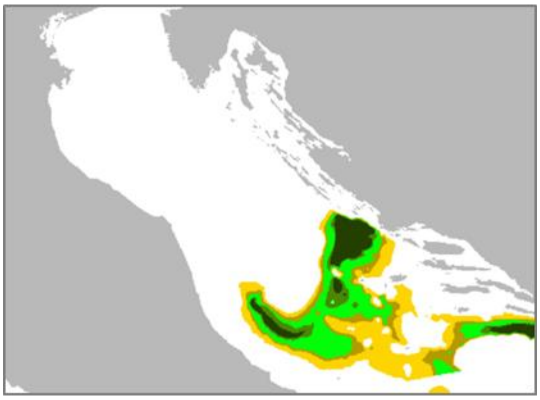


Figure 5.2.1.6.1.2.2. European hake in GSA 17 and 18. Persistent nursery in the GSA 17 from MEDISEH project.

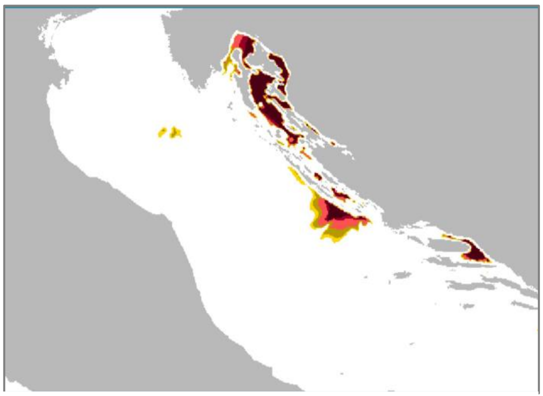


Figure 5.2.1.6.1.2.3. European hake in GSA 17 and 18. Persistent areas of potential spawners in the GSA 17 from

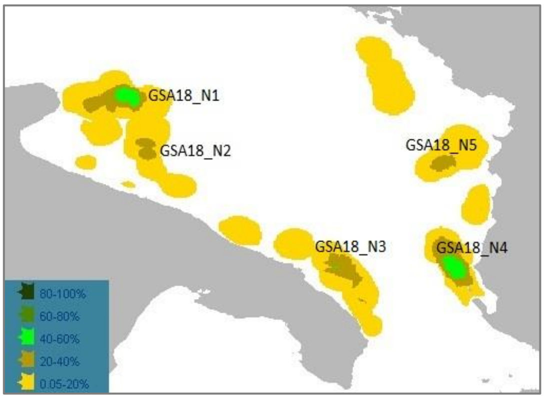


Figure 5.2.1.6.1.2.4. European hake in GSA 17 and 18. Persistent nursery in the GSA 18 from MEDISEH project.

5.2.1.1.7.3 Trends in abundance and biomass

Abundance indeces from MEDITS survey have been calculated using the data available during STECF EWG 15-16 and these data were elaborated using the R routine prepared during the EWG 15-06. Figures 5.2.1.6.1.3.1 and 5.2.1.6.1.3.2 show the trend of abundance of hake in GSA 17 and 18 respectively.

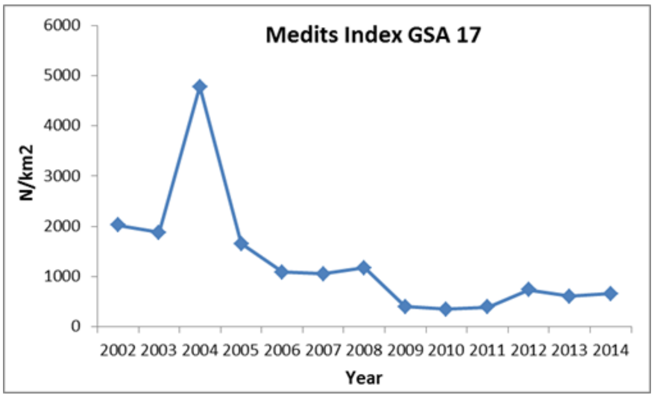


Figure 5.2.1.6.1.3.1. European hake in GSA 17 and 18. Abundance index from MEDITS survey

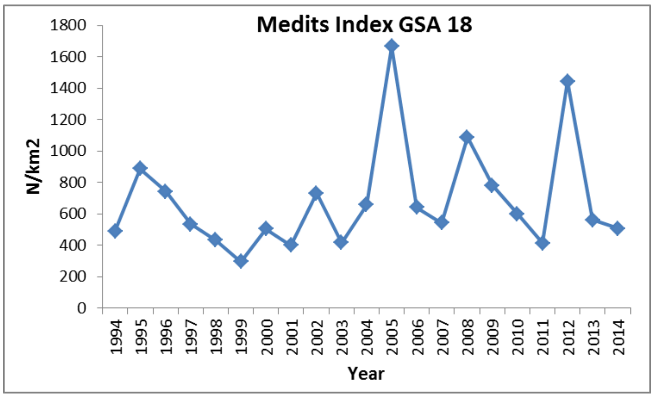


Figure 5.2.1.6.1.3.2. European hake in GSA 17 and 18. Abundance index from MEDITS survey

5.2.1.1.7.4 Trends in abundance by length or age

Hereunder trends of hake abundance by length and year are reported both for GSA 17 (Fig. 5.2.1.6.1.4.1) and 18 (Fig. 5.2.1.6.1.4.2). Values were extracted by the MEDITS survey using r routine developed within EWG 15-06. In GSA 17 LFD are missing for years 1996, 1997 and 2000.

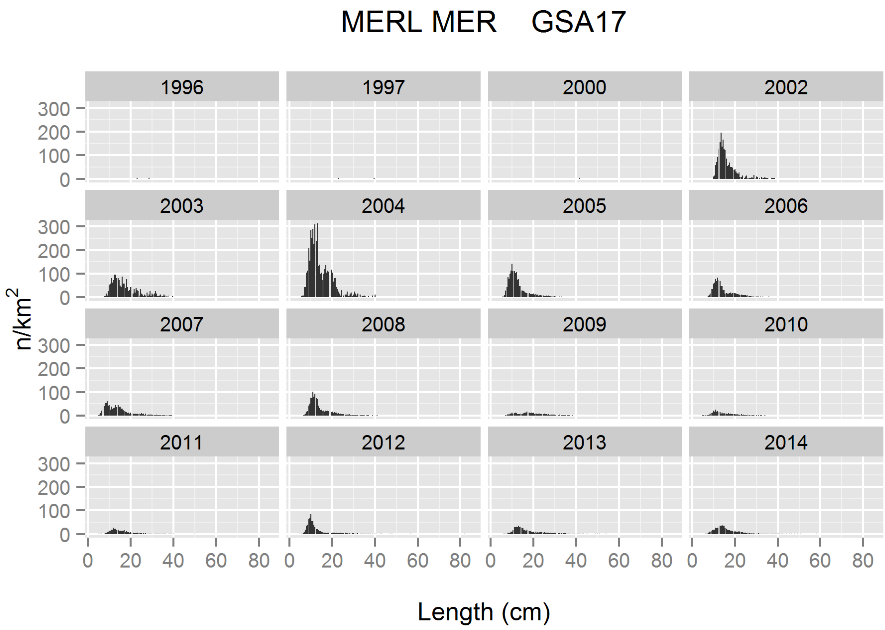


Figure 5.2.1.6.1.4.1. European hake in GSA 17 and 18. Density indices (N/km^2) by length class in GSA 17, 1996-2014. Sex combined.

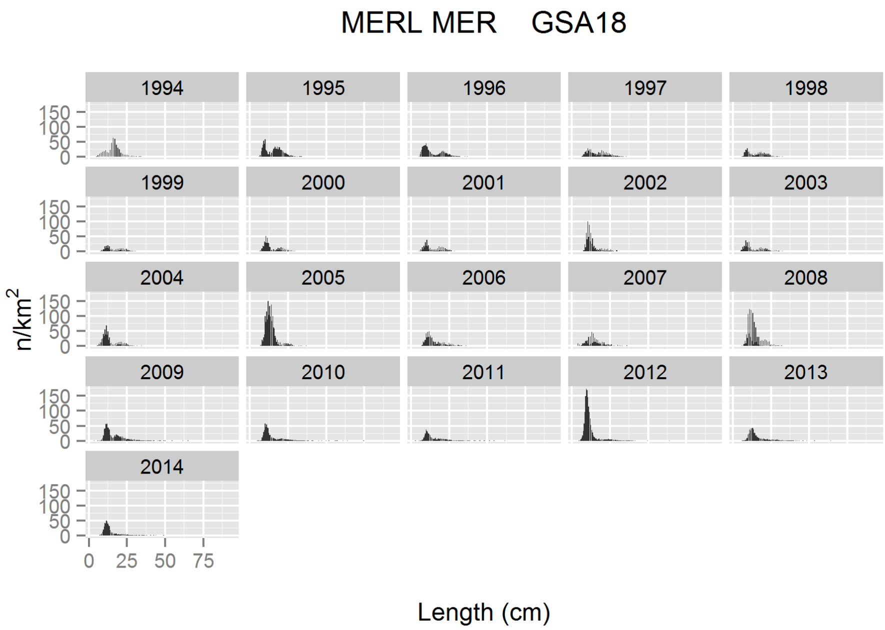


Figure 5.2.1.6.1.4.2. European hake in GSA 17 and 18. Density indices (N/km^2) by length class in GSA 18, 1994-2014. Sex combined.

Stock Assessment

5.2.1.1.8 Methods: XSA

Extended survivor analysis (XSA) was carried out using the FLR libraries.

5.2.1.1.9 Input data

Data available from DCF were integrated with data from Albania and Montenegro, provided by the AdriaMed working group and already used for the stock assessment of hake in GSA 18 presented at the last GFCM (Rome, 2015). Data from Croatia before joining European Union (years from 2008 to 2012) were provided as well by AdriaMed and were already used in the stock assessment of hake in GSA 17 presented at the GFCM (2014). Considering these information, the time series of this stock assessment was fixed between years 2008 and 2014.

Input data requested by XSA are: catch numbers-at-age, mean weight-at-age, catches, proportion of mature individuals by age, natural mortality by age and tuning index by age. In this case two tuning indexes were considered, one for GSA 17 and one for GSA 18. Age compositions for both catches and surveys were estimated performing an age slicing with the LFDA 5.0 software.

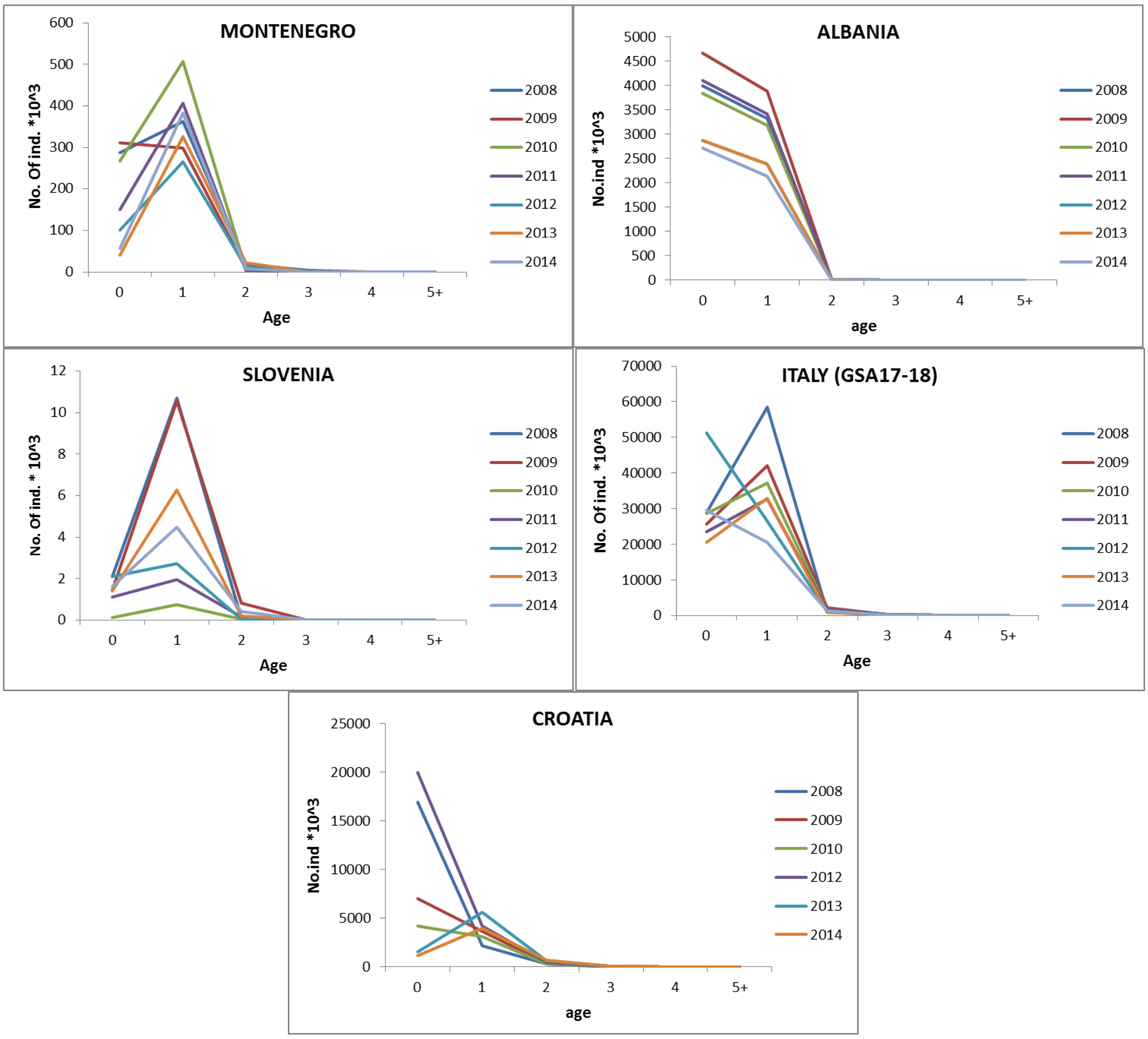


Figure 5.2.1.7.2.1. European hake in GSA 17 and 18. Catch at age composition by country.

The following tables summarize the input data used in the stock assessment.

Table 5.2.1.7.2.1. European hake in GSA 17 and 18. Catch numbers-at-age matrix (thousands).

Age/Year	2008	2009	2010	2011	2012	2013	2014
0	55920	37085	36235	38423	74418	39155	51780
1	63122	49371	43694	39332	33156	39096	25835
2	1322	2518	1993	2080	1485	1603	1999
3	311	210	306	259	274	178	111
4	115	73	116	74	36	53	48

5+	26	61	59	97	50	16	46

Table 5.2.1.7.2.3. European hake in GSA 17 and 18. Catches (landings+discard) in tonnes.

Year	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
Tonnes	8309	7938	6924	6681	6216	6598	5344

Table 5.2.1.7.2.3. European hake in GSA 17 and 18. Weights-at-age (kg).

Age/Year	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
0	0.021	0.025	0.026	0.024	0.020	0.025	0.022
1	0.093	0.109	0.099	0.103	0.107	0.117	0.111
2	0.460	0.429	0.440	0.467	0.427	0.445	0.481
3	1.149	1.055	1.096	1.051	1.104	1.071	1.161
4	1.868	1.955	1.900	1.953	1.850	1.822	1.921
5+	2.830	3.106	3.358	3.311	3.312	3.098	3.654

Table 5.2.1.7.2.4. European hake in GSA 17 and 18. Maturity and natural mortality by age.

Age	**0**	**1**	**2**	**3**	**4**	**5+**
Mat	0	0.12	0.92	1	1	1
M	1.16	0.53	0.40	0.35	0.32	0.32

Table 5.2.1.7.2.5. European hake in GSA 17 and 18. MEDITS index by age for GSA 17.

Age/Year	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
0	647	139	179	205	418	283	328
1	130	116	52	58	67	112	101
2	11	8	6	4	7	13	8
3	2	0	0	0	0	1	1
4	1	0	0	0	0	0	0
5+	0	0	0	0	0	0	0

Table 5.2.1.7.2.6. European hake in GSA 17 and 18. MEDITS index (n/km^2) by age for GSA 18.

Age/Year	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
0	919	564	480	319	1345	445	431
1	151	200	109	87	90	98	63
2	5	14	7	4	5	11	11
3	2	2	3	2	1	1	3
4	0	1	1	1	1	1	1
5+	0	0	1	0	0	1	0

5.2.1.1.10 Results

Sensitivity analyses were conducted to assess the effect of the main settings of the XSA.
Five runs were compared considering the following values: 0 for rage, 4 for qage, 3 for shk.yrs, 2 for shk.ages and values from 0.5 to 2.5 for fse. Results showed that the best fitting was obtained using fse=2 (corresponding to Run 4), and it was chosen on the base of the best results in terms of residuals and XSA diagnostics.
Comparison among runs is showed in figure 5.2.1.7.3.1. Residuals for the different runs are shown in table 5.2.1.7.3.1, whereas figure 5.2.1.7.3.2 represents the residuals for Run 4.
XSA models stability is evaluated by the retrospective analysis, represented for Run 4 in figure 5.2.1.7.3.3. Following internal consistency of catches and survey indexes for the best model (Run 4) are shown (Figs. 5.2.1.7.3.4, 5.2.1.7.3.5, 5.2.1.7.3.6).

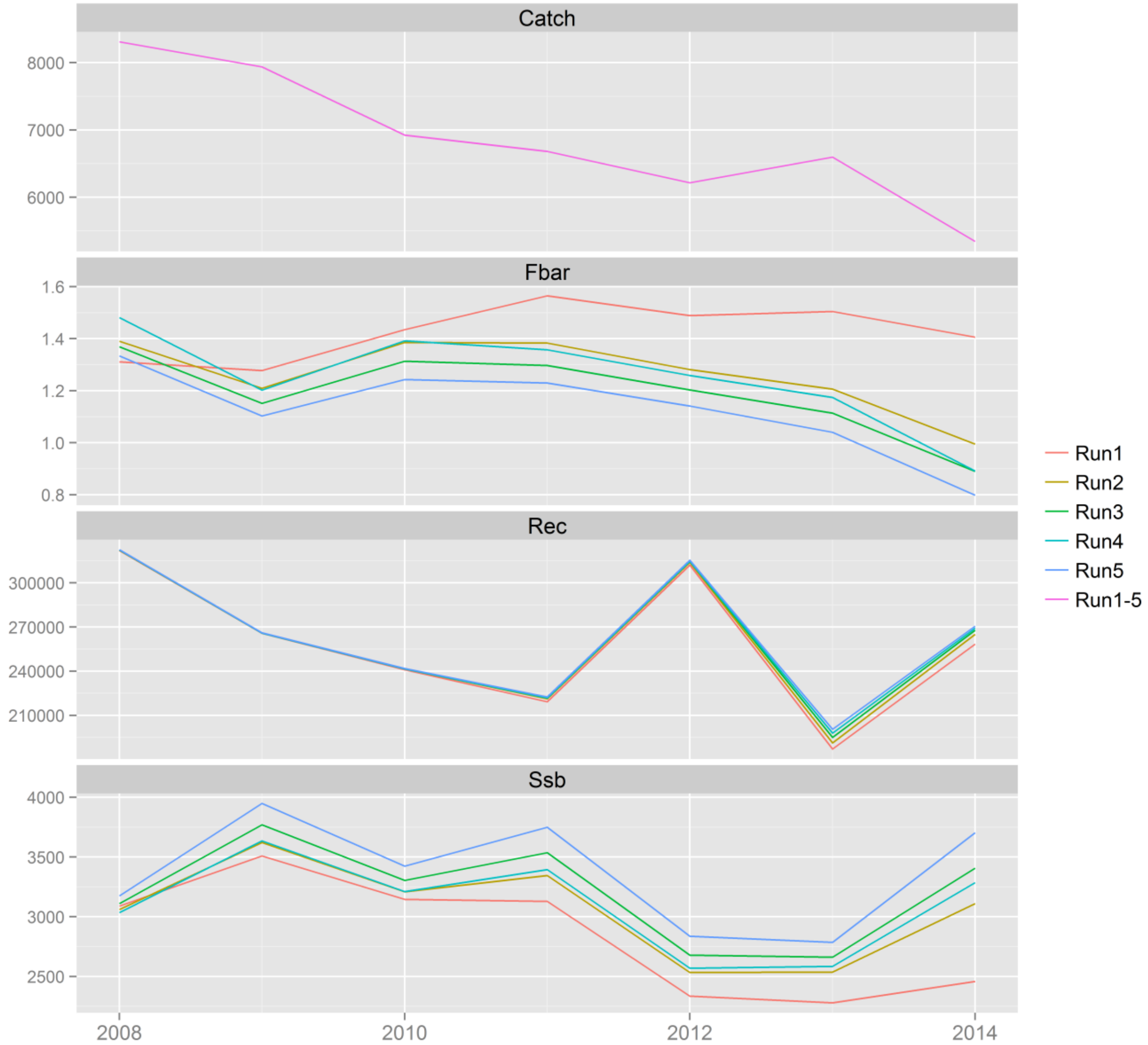


Figure 5.2.1.7.3.1. European hake in GSA 17 and 18. Sensitivity analysis on fse parameter.

Table 5.2.1.7.3.1. European hake in GSA 17 and 18. XSA run comparison: minimum, maximum and average residuals expressed as absolute value.

				MEDITS GSA 17			MEDITS GSA 18		
	fse	**rage**	**qage**	**Min Residual**	**Max Residual**	**Average (abs value)**	**Min Residual**	**Max Residual**	**Average (abs value)**
Run 1	0.5	0	4	-3.47	2.97	0.80	-1.38	0.95	0.29
Run 2	1	0	4	-3.42	3.79	0.77	-0.56	0.54	0.17
Run 3	1.5	0	4	-3.46	4.04	0.77	-0.53	0.57	0.15
Run 4	2	0	4	-3.47	4.13	0.78	-0.53	0.58	0.14
Run 5	2.5	0	4	-3.50	4.21	0.77	-0.52	0.60	0.14

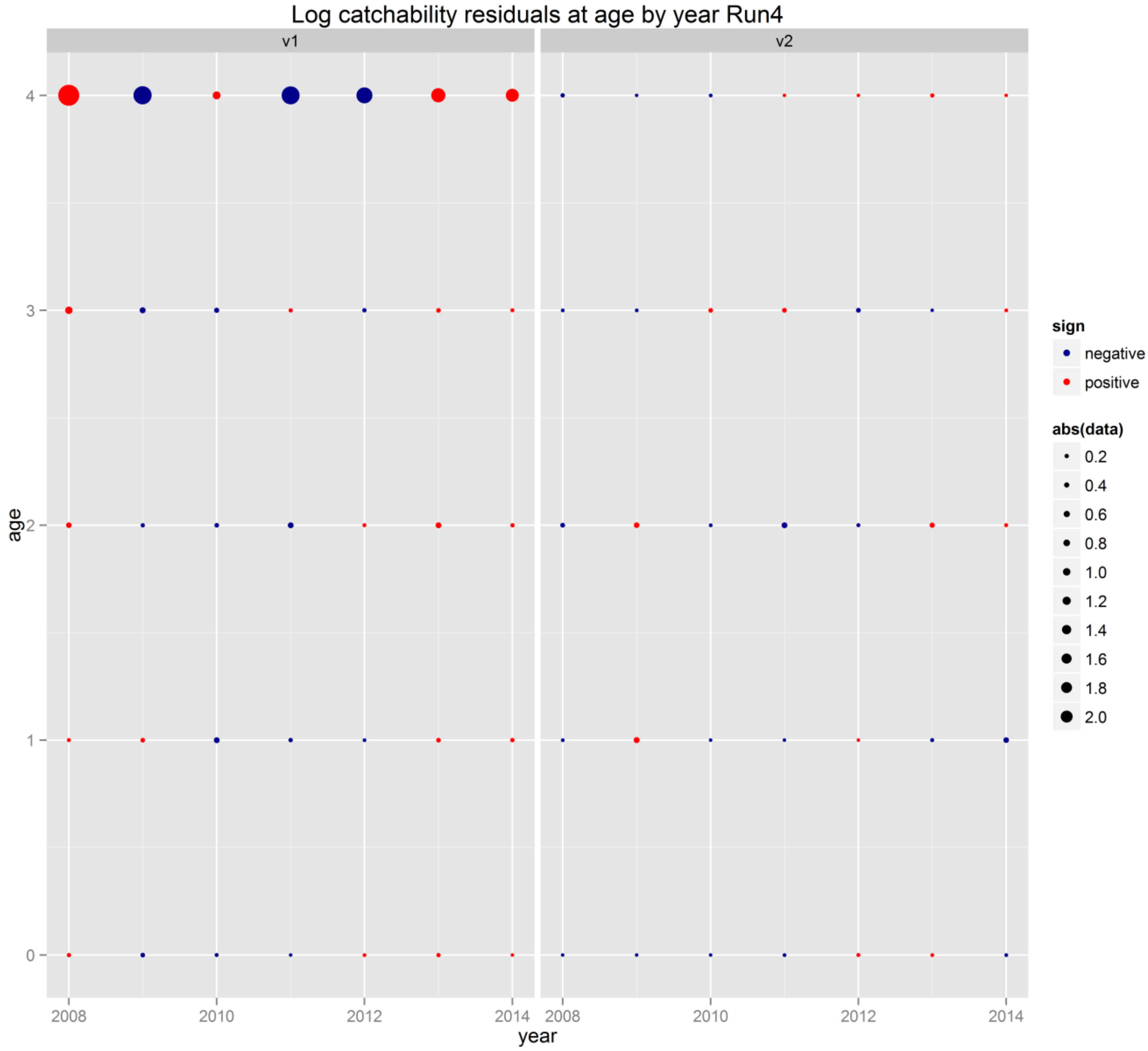


Figure 5.2.1.7.3.2. European hake in GSA 17 and 18. XSA residuals for MEDITS survey in GSA 17 on the left and for MEDITS survey in GSA 18 on the right.

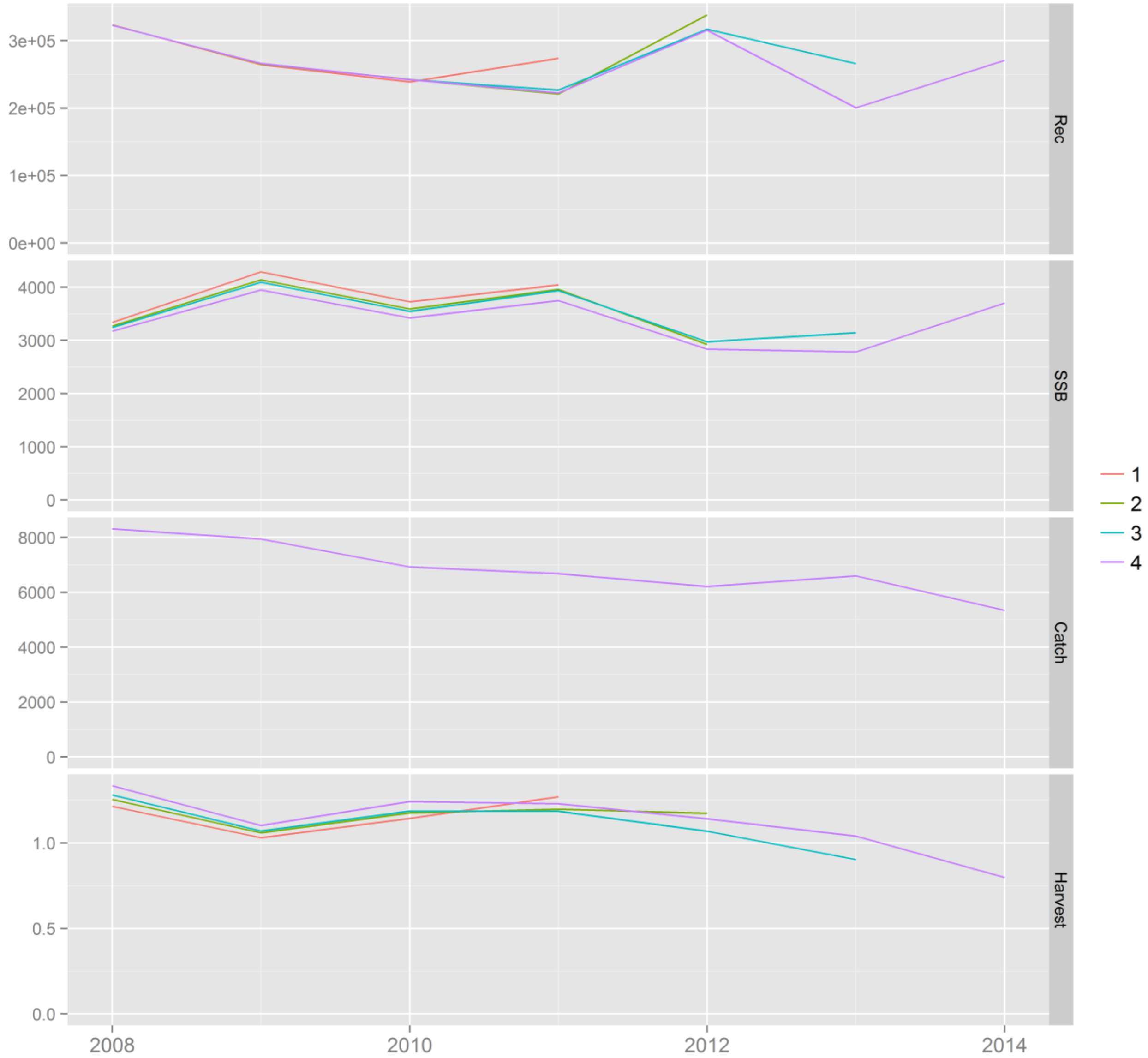


Figure 5.2.1.7.3.3. European hake in GSA 17 and 18. XSA retrospective analysis on run 4.

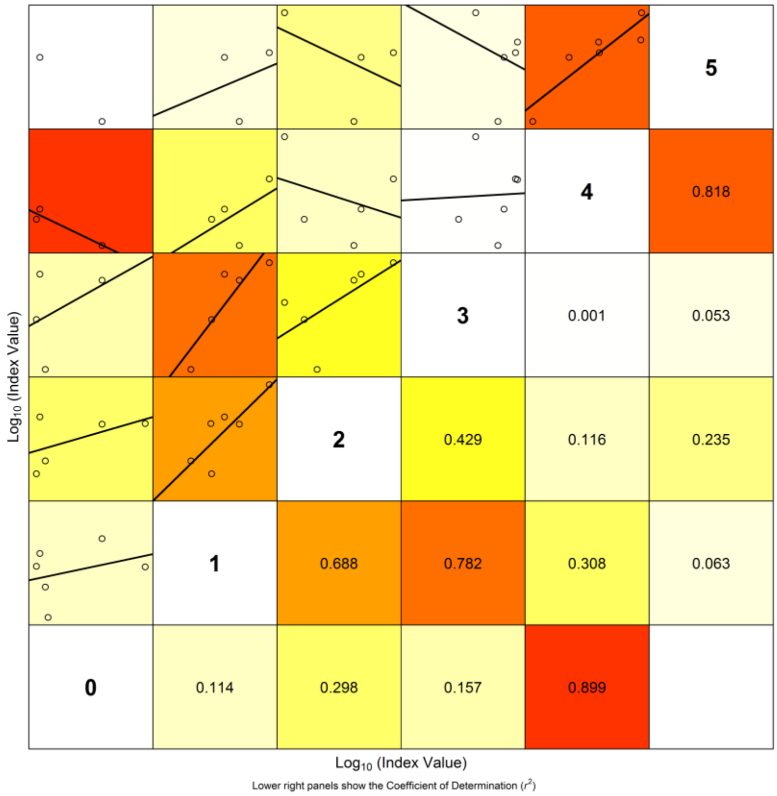


Figure 5.2.1.7.3.4. European hake in GSA 17 and 18. Internal consistency of catches.

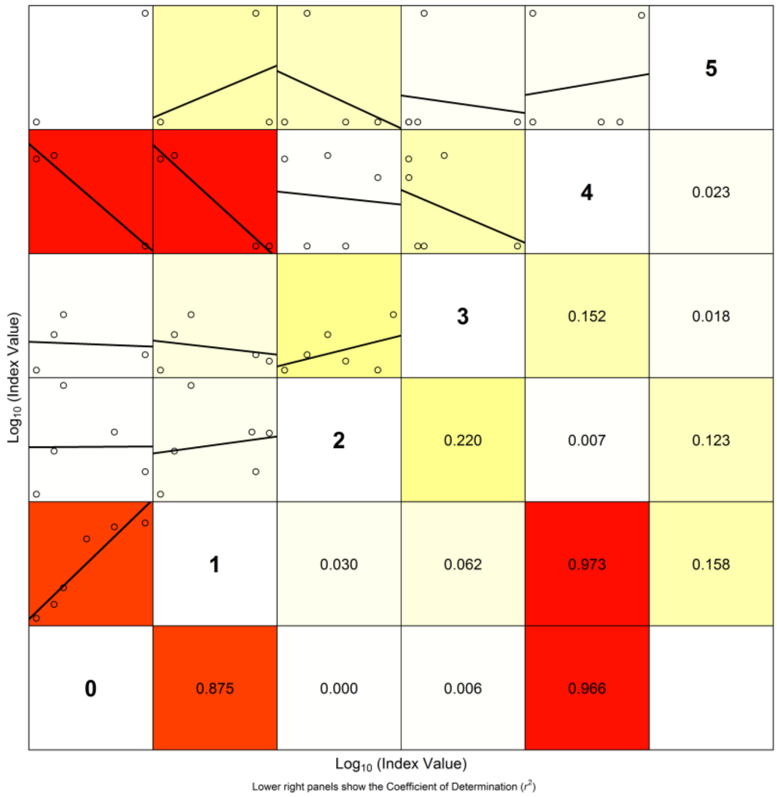


Figure 5.2.1.7.3.5. European hake in GSA 17 and 18. Internal consistency of MEDITS survey in GSA 17.

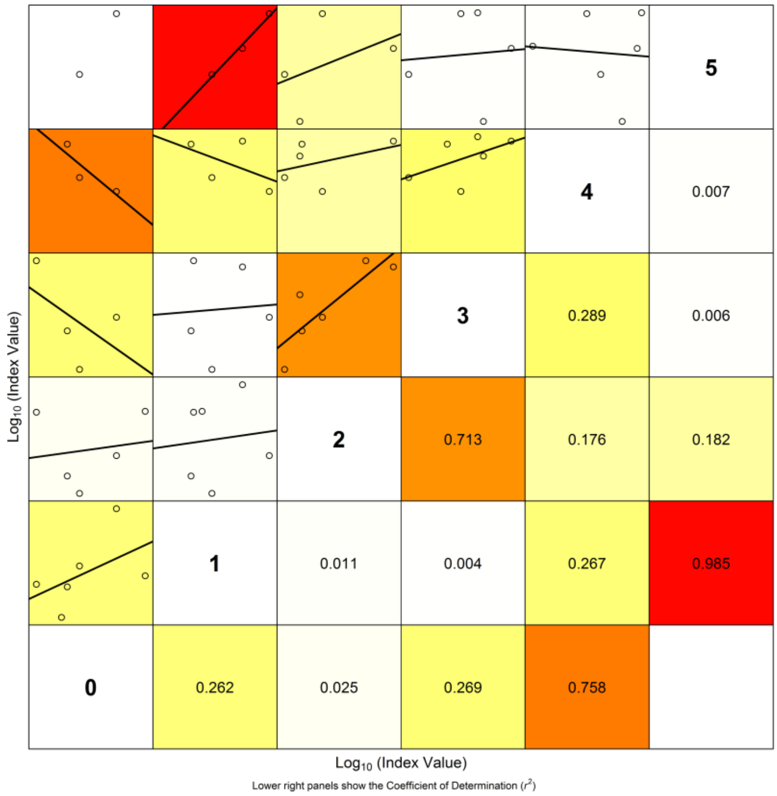


Figure 5.2.1.7.3.6. European hake in GSA 17 and 18. Internal consistency of MEDITS survey in GSA 18.

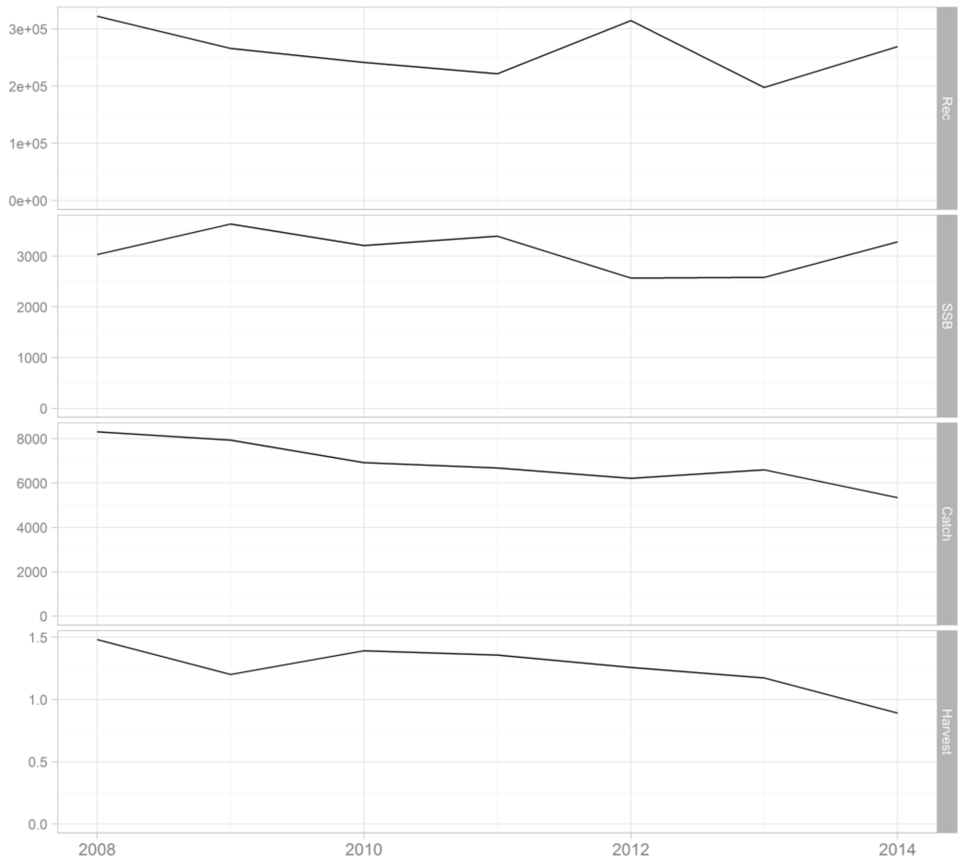


Figure 5.2.1.7.3.7. European hake in GSA 17 and 18. Results for Run 4 (Final run).

The following tables summarize the results from XSA.

Table 5.2.1.7.3.2. European hake in GSA 17 and 18. XSA summary results.

	Fbar0-4	Recruitment (thousands)	SSB (t)	TB (t)
2008	1.48	322266	3034	17123
2009	1.20	265883	3635	17009
2010	1.39	241484	3211	15136
2011	1.36	221709	3394	13775
2012	1.26	314615	2569	13552
2013	1.17	197854	2585	13436
2014	0.89	269125	3285	13162

Table 5.2.1.7.3.3. European hake in GSA 17 and 18. Stock number at age in thousands estimated by XSA from 2008 to 2014.

	2008	2009	2010	2011	2012	2013	2014
0	322266	265883	241484	221709	314615	197854	269125
1	89171	69716	62587	55414	47990	56961	40101
2	2357	3932	3073	3240	2389	2732	3447
3	577	492	564	422	462	380	511
4	151	145	170	141	80	95	117
5+	32	119	83	180	108	27	110

Table 5.2.1.7.3.4. European hake in GSA 17 and 18. Harvest at age estimated by XSA from 2008 to 2014.

	2008	2009	2010	2011	2012	2013	2014
0	0.37	0.29	0.31	0.37	0.55	0.44	0.42
1	2.59	2.59	2.43	2.61	2.33	2.27	1.85
2	1.16	1.53	1.58	1.54	1.43	1.27	1.24
3	1.03	0.71	1.04	1.31	1.23	0.82	0.30
4	2.26	0.89	1.60	0.95	0.75	1.07	0.65
5+	2.26	0.89	1.60	0.95	0.75	1.07	0.65

Reference points

5.2.1.1.11 Methods

The yield per recruit analysis (YpR) was computed using the FLBRP routine. Thus it was possible to estimate some F-based Reference Points and $F_{0.1}$ was considered as a proxy of F_{MSY}.

5.2.1.1.12 Input data

Input data were the same used for the XSA.

5.2.1.1.13 Results

The FLBPR package permited to estimate the reference points, reported in table 5.2.1.8.3.1. The estimated $F_{0.1}$ value is 0.16 and it represents also a proxy of F_{MSY}.

Table 5.2.1.8.3.1. European hake in GSA 17 and 18. Reference points estimated by the Yield per Recruit analysis.

Refpt	Harvest	Yield	Rec	Ssb	Biomass
Virgin	0	0	1	1.14	1.20
Msy	0.23	0.06	1	0.34	0.40
Crash	16.05	0.02	1	0	0.02
F0.1	0.16	0.06	1	0.47	0.53
Fmax	0.23	0.06	1	0.34	0.40
Spr.30	0.23	0.06	1	0.34	0.40

Fig. 5.2.1.8.3.1. European hake in GSA 17 and 18. Plots of the YPR analysis.

Data quality

The assessement of *Merluccius merluccius* in GSA 17 and 18 was pursued using all the data available. Specifically, for GSA 18 data from the last GFCM stock assessment were used, whereas from GSA 17 data provided by STECF, combined with Croatian data collected in the framework of Adriamed for years from 2008 to 2012, were employed.

EWG 15-16 data needed some reconstructions. In particular, for those years where discard is reported but without length composition, this was reconstructed from the information presented in previous or following years. Moreover, some landings data and size structure of the eastern countries were reconstructed from the information presented in most recent years.

Short term predictions 2016-2018

5.2.1.1.14 Method

A deterministic short term prediction for the period 2015 to 2017 was performed using the FLR routines provided by JRC and based on the results of the XSA stock assessments performed during EWG 15-16.

5.2.1.1.15 Input parameters

Input parameters were the same used in the XSA analysis and showed previously.

5.2.1.1.16 Results

Table 5.2.1.10.3.1. European hake in GSA 17 and 18. Short term forecast. Basis: F(2015) = mean(Fbar 0-4 2012-2014)= 1.11; R(2015) = geometric mean of the recruitment of the last 3 years; R = 255874 (thousands); SSB(2014) = 3285 t; Catch (2014)= 5345 t.

Rationale	Ffactor	Fbar	Catch 2014	Catch 2015	Catch 2016	Catch 2017	SSB 2016	SSB 2017	Change SSB 2016-2017(%)	Change Catch 2014-2016(%)
Zero catch	0	0.00	5345	7667	0	0	3810	17886	369	-100
High long term yield (F0.1)	0.15	0.162	5345	7667	1813	3764	3810	13822	263	-66
Status quo	1	1.10	5345	7667	7306	7214	3810	3679	-3	37
Different Scenarios	0.1	0.11	5345	7667	1272	2781	3810	15010	294	-76
	0.2	0.22	5345	7667	2363	4640	3810	12639	232	-56
	0.3	0.33	5345	7667	3305	5853	3810	10681	180	-38
	0.4	0.44	5345	7667	4121	6615	3810	9059	138	-23
	0.5	0.55	5345	7667	4832	7066	3810	7714	102	-10
	0.6	0.66	5345	7667	5455	7303	3810	6595	73	2
	0.7	0.77	5345	7667	6003	7394	3810	5663	49	12
	0.8	0.88	5345	7667	6488	7389	3810	4883	28	21
	0.9	0.99	5345	7667	6920	7321	3810	4229	11	29
	1.1	1.21	5345	7667	7653	7084	3810	3215	-16	43
	1.2	1.32	5345	7667	7966	6942	3810	2822	-26	49
	1.3	1.42	5345	7667	8250	6795	3810	2488	-35	54
	1.4	1.53	5345	7667	8510	6648	3810	2203	-42	59
	1.5	1.64	5345	7667	8747	6504	3810	1959	-49	64
	1.6	1.75	5345	7667	8965	6366	3810	1750	-54	68
	1.7	1.86	5345	7667	9166	6235	3810	1568	-59	71
	1.8	1.97	5345	7667	9352	6110	3810	1412	-63	75
	1.9	2.08	5345	7667	9526	5992	3810	1275	-67	78
	2	2.19	5345	7667	9687	5882	3810	1156	-70	81

Short term predictions 2015-2017 by fleet

5.2.1.1.17 Method

A deterministic short term prediction by fleet for the period 2015 to 2017 was performed using the FLR routines provided by JRC and based on the results of the XSA stock assessments performed during EWG 15-16.

5.2.1.1.18 Input parameters

The same parameters used in the short term by single fleet were used.

5.2.1.1.19 Results

Results from short term predictions by fleet are shown in Table 5.2.1.11.3.1 and Figure 5.2.1.11.3.1. The fleets considered are five, each one represents a country.

Table 5.2.1.11.3.1. European hake in GSA 17 and 18 - Short term forecast by fleet.

fleet	year	catches	qname	partial_f
fl.ita	2015	5954.378	fsq * 1	0.883607
fl.ita	2015	5954.378	f0.1	0.883607
fl.hrv	2015	963.9344	fsq * 1	0.169236
fl.hrv	2015	963.9344	f0.1	0.169236
fl.slo	2015	0.740505	fsq * 1	8.25E-05
fl.slo	2015	0.740505	f0.1	8.25E-05
fl.alb	2015	407.5191	fsq * 1	0.037114
fl.alb	2015	407.5191	f0.1	0.037114
fl.mtn	2015	50.06379	fsq * 1	0.005917
fl.mtn	2015	50.06379	f0.1	0.005917
fl.ita	2016	6106.062	fsq * 1	0.883607
fl.ita	2016	1528.314	f0.1	0.128999
fl.hrv	2016	997.2797	fsq * 1	0.169236
fl.hrv	2016	230.5077	f0.1	0.024707
fl.slo	2016	0.767916	fsq * 1	8.25E-05
fl.slo	2016	0.202179	f0.1	1.20E-05
fl.alb	2016	416.628	fsq * 1	0.037114
fl.alb	2016	106.0639	f0.1	0.005418
fl.mtn	2016	51.74665	fsq * 1	0.005917
fl.mtn	2016	13.50872	f0.1	0.000864
fl.ita	2017	6149.423	fsq * 1	0.883607
fl.ita	2017	3042.974	f0.1	0.128999
fl.hrv	2017	1012.407	fsq * 1	0.169236
fl.hrv	2017	615.218	f0.1	0.024707
fl.slo	2017	0.772107	fsq * 1	8.25E-05
fl.slo	2017	0.426389	f0.1	1.20E-05
fl.alb	2017	416.8021	fsq * 1	0.037114
fl.alb	2017	144.2713	f0.1	0.005418
fl.mtn	2017	52.02482	fsq * 1	0.005917
fl.mtn	2017	25.26831	f0.1	0.000864

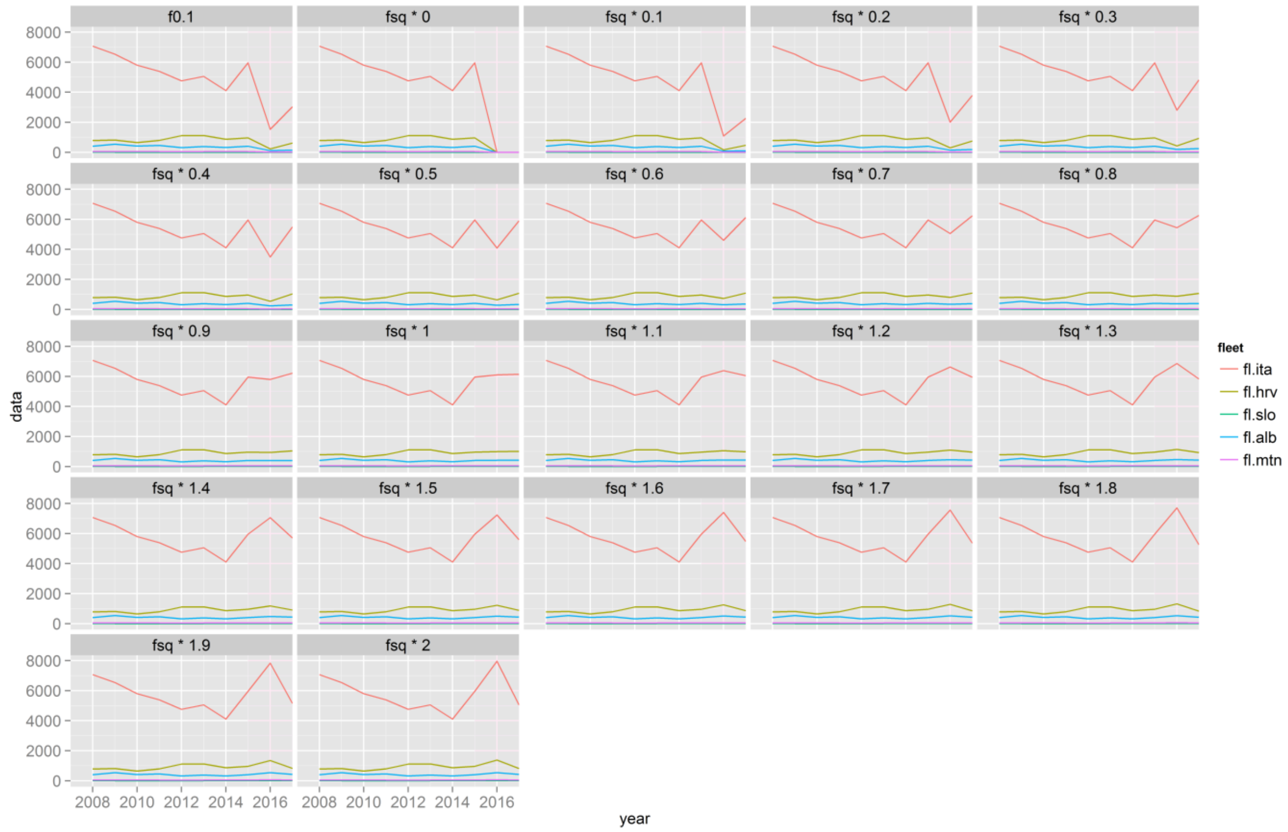


Figure 5.2.1.11.3.1. European hake in GSA 17 and 18. Catches by fleet at scenario from short term forecast by fleet.

Medium term predictions

Not applicable.

5.2.1.1.20 Method

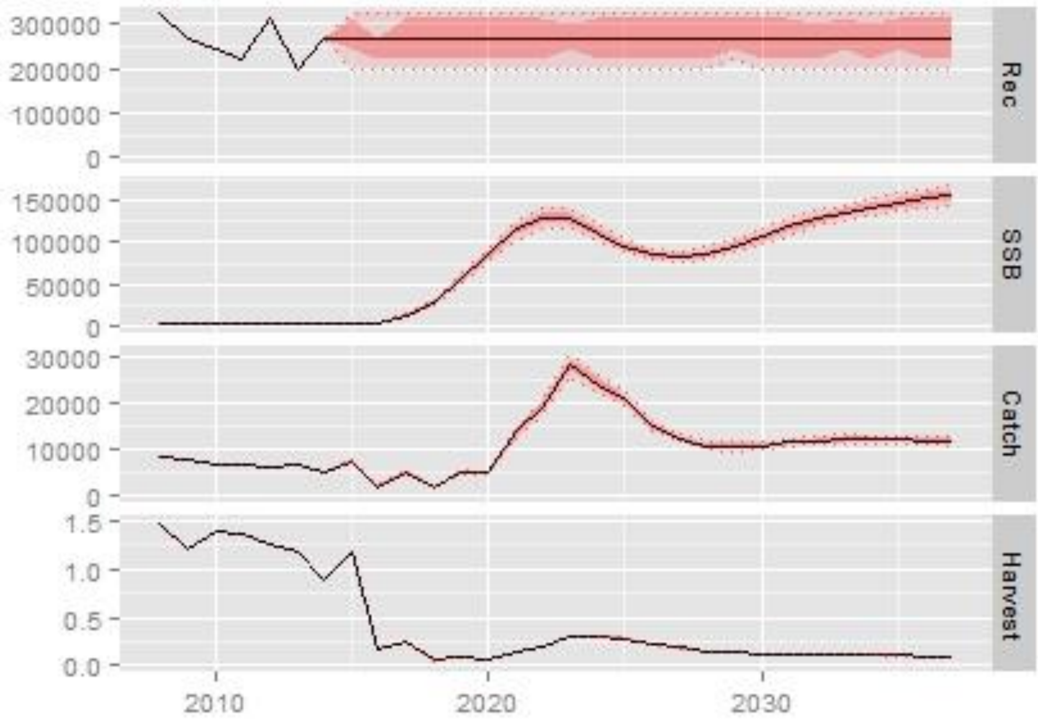
Not applicable.

Stock advice

The $F_{current}$ is equal at 0.89. This value is considerably larger than $F_{0.1}$ (0.16), chosen as proxy of F_{MSY} and as the exploitation reference point consistent with long term yields (F_{MSY}), which indicates that the stock of hake in GSA 17 and 18 is exploited unsustainably. Catches of hake in 2016 consistent with $F_{0.1}$ (0.16) would not exceed 1813 tonnes.

Management strategy evaluation

A Management Strategy Evaluation was run to evaluate if the MSY ranges were precautionary. The F_{MSY} ranges were derived using the formula provided by STECF EWG 15-09. F ranges results were F_{upper}=0.23 and F_{lower}=0.11. B_{lim} was estimated as 2569 (t). Figure 5.2.1.14.1. shows the results of the MSE. The probability of the stock to fall below B_{lim} fishing at F_{upper} was estimated to be 0.



F_{MSY}	F_{upp}	F_{low}	B_{lim} (tons)	B_{pa} (tons)
0.16	0.23	0.11	2569	3596

Figure 5.2.1.14.1. European hake in GSA 17 and 18. Management Strategy Evaluation.

5.2.2 STOCK ASSESSMENT OF HAKE IN GSA 19

Stock Identification

The GSA 19 covers a surface of about 16500 km^2 in the depth range between 10-800 m along a coast line of about 1000 km (Italian regions of Apulia, east Lucania, east Calabria and east Sicily). The Northern Ionian Sea is geo-morphologically divided in two sectors by the Taranto Valley, which is exceeding 2200 m in depth. The former is located between the Taranto Valley and the Apulia region and is represented by a broad continental shelf. Along Calabria and Sicily instead, the shelf is generally very limited with the shelf break located at a depth varying between 30 and 100 m. Adult specimens of European hake are mainly found on the slope. On the contrary, recruits and pre-adult are mainly distributed on the shelf and shelf-break upper slope.

In the framework of the Medits and Grund surveys carried out in the GSA 19, *M. merluccius* has been caught at depth ranging from 14 to 800 m.

Hake is one of the most important commercial resources in the GSA 19, being with red mullet and deep-water pink shrimp a key species of fishing assemblages in the Ionian Sea (GSA 19).

According to the main outcomes of the EU StockMed project carried out in MAREA framework, hake in the GSA 19 seems to belong to a wider stock unit distributed on the Central Mediterranean Sea. However, for the purposes of this assessment it is assumed a single, homogeneous stock confined in GSA 19 (Figure 5.2.2.1.1.).

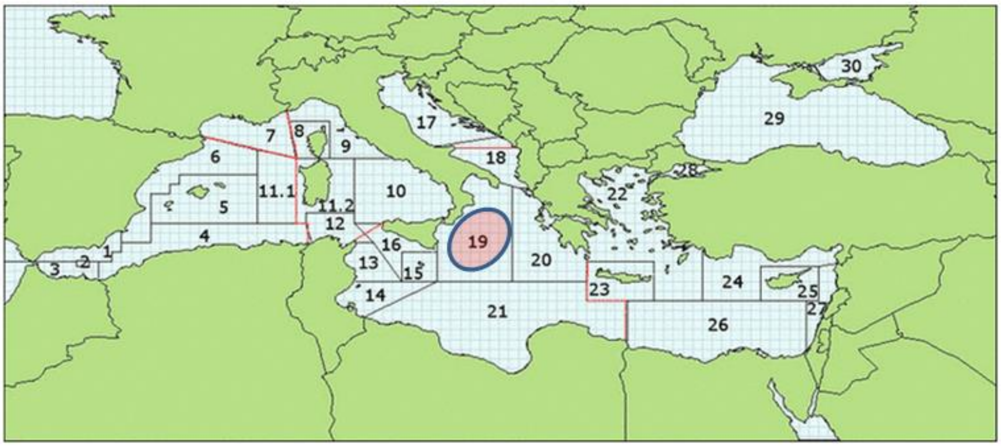


Figure 5.2.2.1.1. Geographical location of GSA 19.

European is considered fully recruited to the bottom at 10 cm TL (from SAMED, 2002). The length structures from trawl surveys are generally dominated by juveniles, while large size individuals are rare. This pattern might be also due to the different vulnerability of older fish (Abella and Serena, 1998) beside the effect of high exploitation rates. Shelter for adults of this species can be represented by many submarine canyons located along the coasts of this GSA. The few large European hake caught during trawl surveys are generally females and inhabit deeper waters.

5.2.2.2 Growth

Estimates of growth parameters were achieved during the SAMED project (SAMED, 2002) by the analysis of length frequency distributions.

In GSA19 Maiorano et al. (2010) estimated in the area the following growth paramters:

F	Linf= 82.5	K= 0.102	t0=-1.466
M	Linf=67.5	K= 0.177	t0=-0.732

In the DCF framework the growth has been studied ageing fish by otolith readings using the whole sagitta and thin sections for older individuals. Length frequency distributions were also analyzed using techniques as Batthacharya for separation of modal components.
DCF von Bertalanffy growth parameters for each sex were estimated from average length at age using an iterative non-liner procedure that minimizes the sum of the square differences between observed and expected values.
The table 5.2.2.2.1. summarizes the estimates obtained by the DCF Data Call for the von Bertalanffy growth parameters and the length-weight relationship. Only the last three years are reported, given similarities with the previous years.

Table 5.2.2.2.1. Hake in GSA 19. Summary of the estimated obtained by the DCF Data Call for the von Bertalanffy growth parameters and the length-weight relationships.

START_YEAR	END_YEAR	SEX	VB_LINF	VB_K	VB_T0	VB_SIZE_RANGE	A	B	L_W_SIZE_RANGE (g)
2012	2012	C	98	0.115	-0.76	5-82 cm	0.0041	3.1653	1-2250 g
2012	2012	F	98	0.12	-0.73	5-82 cm	0.0041	3.1625	14-1975 g
2012	2012	M	71.5	0.148	-0.9	5-65 cm	0.0047	3.1171	15-1401 g
2013	2013	C	98	0.115	-0.76	5-82 cm	0.0045	3.1405	1-2846 g
2013	2013	F	98	0.12	-0.73	5-82 cm	0.0048	3.1206	15-2846 g
2013	2013	M	71.5	0.148	-0.9	5-65 cm	0.0045	3.1357	13-888 g
2014	2014	C	98	0.115	-0.76	5-82 cm	0.0043	3.1485	3-4265 g
2014	2014	F	98	0.12	-0.73	5-82 cm	0.0043	3.1488	14-4265 g
2014	2014	M	71.5	0.148	-0.9	5-65 cm	0.0047	3.1166	14-610 g

For the purposes of this assessment the following growth parameters have been used for sex combined, according to the choice of setting a fast growth pattern for European hake in the EWG-STECF working group for this species in this area as in other ones of the Mediterranean:

L_∞ =104 cm; K=0.2 (year); t_0=-0.01

However further studies based on different techniques that allow validation are recommended to give insight in this growth pattern, given that these parameters might not be suitable for all the components of the population (e.g., sexes, life stage).

5.2.2.3 Maturity

Spawning season extends over all year round with maturity peak around December-March.
Proportion of mature individuals at length every three years was obtained by DCF (Figure 5.2.2.3.1.).
Size at first maturity was estimated from commercial samples using a generalized linear models (GLMs) with logistic link to describe the proportion of adult individuals on the length as independent variable (ICES, 2008). Specimens were considered adults at stage 2b (recovering), 2c (maturing), 3 (mature), 4a (spent) and 4b (resting), and immature at stage 1 (immature) and 2a (virgin developing).
The estimated size at first maturity in about 33.6 cm (maturity range 2.4 cm) for females and 17.5 cm (maturity range 1.1 cm) for males.

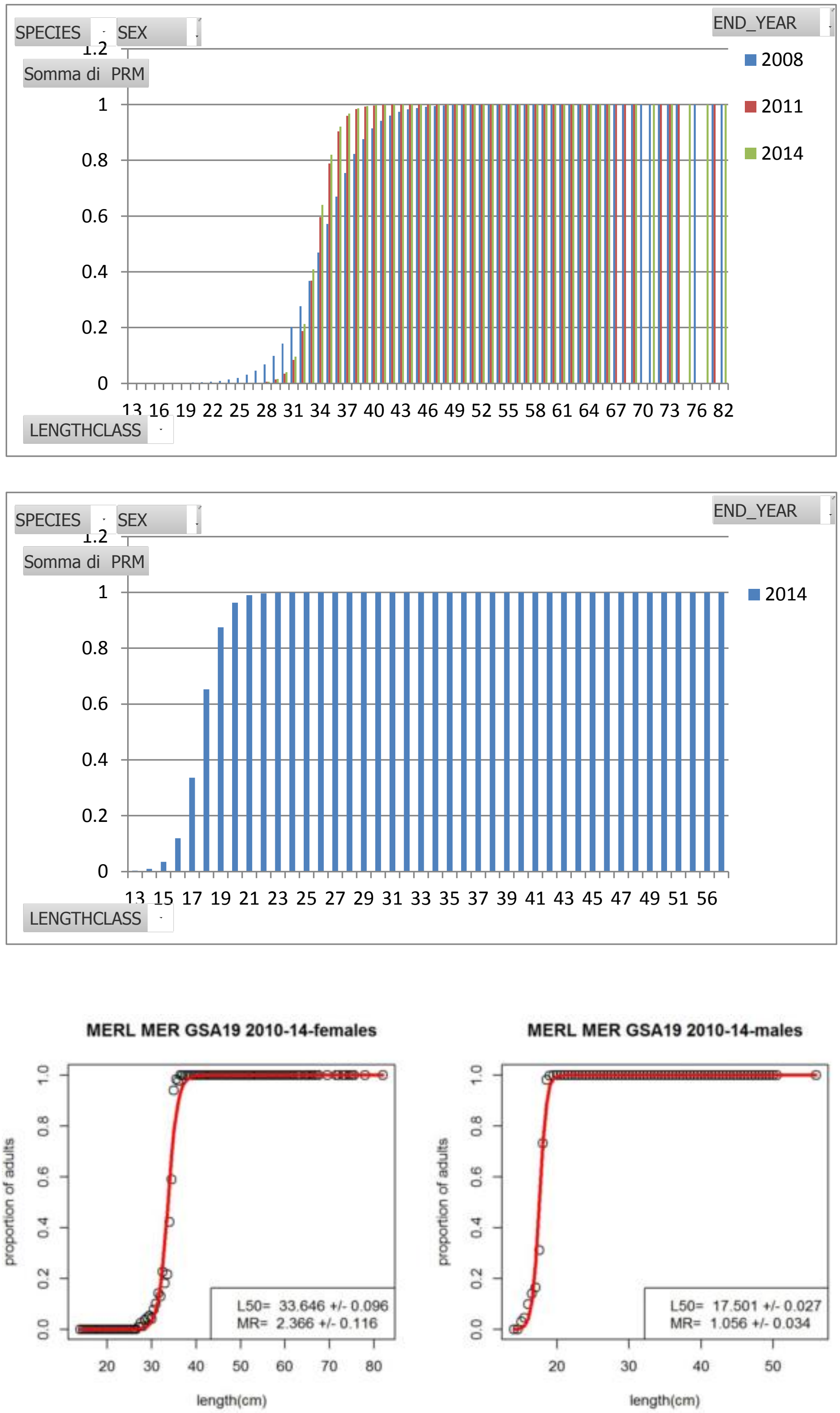


Figure 5.2.2.3.1. Hake in GSA 19. Proportion of mature individuals at length females (upper panel) and male (intermediate panel) from DCF data call. Maturity ogives of females and males estimated on the last 4 years of the DCF data.

Sex ratio (F/(F+M)) by length and year obtained by DCF is reported in the Figure 5.2.2.3.2.

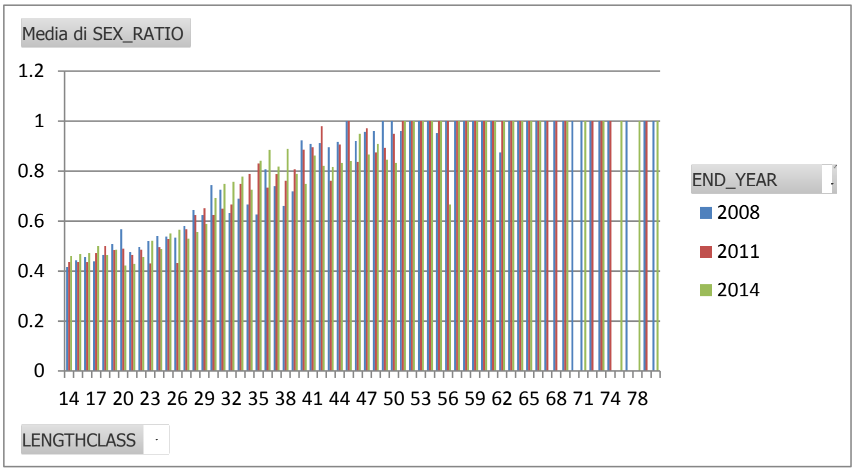


Figure 5.2.2.3.2. Hake in GSA 19. Sex ratio (F/(F+M)).

For the purposes of this assessment the following vector of maturity at age (table 5.2.2.3.1.) has been used, in line with the growth parameters selected for the assessment.

Table 5.2.2.3.1. Hake in GSA 19. Maturity proportion at age adopted in the present assessment.

Age	Proportion of matures
0	0
1	0.2
2	0.9
3	1
4+	1

5.2.2.4 Natural mortality

For the purposes of this assessment the following vector of natural mortality at age (Table 5.2.2.4.1.), estimated according to Prodbiom method (Abella et al., 1997), has been used in line with the growth parameters selected for the assessment.

Table 5.2.2.4.1. Hake in GSA 19. Vector of natural mortality adopted in the present assessment.

Age	Natural mortality at age
0	1.16
1	0.53
2	0.4
3	0.35
4+	0.32

5.2.2.5 Fisheries

5.2.2.5.1 General description of the fisheries

In this area the relatively narrow continental shelf has clearly favoured artisanal fishing systems trammel nets, gillnets, long lines, hand lines, pots, harpoons and "*menaide*" nets), which are used by about 60% of the boats, while 17% use trawl nets.
If large pelagics are excluded, European hake is the most abundant species, accounting for around 9% of production. It is followed by deep water rose shrimp (~5%), giant red shrimp and blue and red shrimp (~4%). These, together with red mullet, octopus and cuttlefish, are the most highly valued species in economic terms.
In the North-Western Ionian Sea fishing occurs from coastal waters to about 800 m depth. Gallipoli, Taranto, Crotone and Catania represent the most important fisheries although with a different distribution of the fishing effort.
European hake is mostly targeted by trawlers, but also by small scale fisheries using nets and bottom long-lines. Fishing grounds are located on the soft bottoms of continental shelf and the upper part of continental slope along the coasts of the whole GSA. Catches from trawlers are from a depth range between 50-60 m to 500 m and hake occurs with other important commercial species like *Illex coindetii*, *M. barbatus*, *P. longirostris*, *Eledone* spp., *Lophius* spp.

5.2.2.5.2 Management regulations applicable in 2015

In Italy management regulations are based on technical measures, as closed number of fishing licenses and area limitation (distance from the coast and depth). In order to limit the over-capacity of fishing fleet, the Italian fishing licenses have been fixed since the late eighties and the fishing capacity has been gradually reduced. Other measures on which the management regulations are based regards technical measures (mesh size), minimum landing sizes (EC 1967/06). Regarding small scale fishery management regulations are based on technical measures related to the height and length of the gears as well as the mesh size opening, minimum landing sizes and number of fishing licenses for the fleet. Regarding long-lines the management regulations are based on technical measures related to the number of hooks and the minimum landing sizes (EC 1967/06), besides the regulated number of fishing licences.
Fishing closure for trawling: 30-45 days in late summer early autumn (not every year applied and not always in the same period).
Cod end mesh size of trawl nets: 40 mm (stretched, diamond meshes) till 30/05/2010. From 1/6/2010 the existing nets have been replaced by a cod end with 50 mm (stretched) diamond meshes.
In 2008 a management plan was adopted, that foresaw the reduction of fleet capacity associated with a reduction of the time at sea.

5.2.2.5.3 Catches

EWG 15-16 received Italian landings data for GSA 19 by fishing gears, which are listed in Table 5.2.2.5.3.1. Figure 5.2.2.5.3.1. shows a decreasing trend of landings, in particular from 2004 to 2007 for the overall catches and then from 2011 to 2014 for trawlers only. Current level of landing is 740 tons compared with 1299 tons in 2004.

Table 5.2.2.5.3.1. Hake in GSA 19. Landings from DCF by year, country and gear. The fishing technique targeting hake are highlighted.

Sum of landings	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
CYP							**0.2**				
OTB							0.2				

ITA	1298.7	1271.2	1629.1	882.3	932.1	998.6	838.8	810.2	674.8	760.3	740.0
-1	0.1	0.0							2.0		
GND									0.6		
GNS	35.1	19.9	7.7		37.4	25.4	16.6	21.1	34.5	153.3	120.4
GTR	6.9	8.5	91.8	24.6	16.2	25.3	17.9	17.9	56.7	134.5	89.6
LLD			63.6	11.6	0.3			0.1	9.5		
LLS	203.5	146.7	136.2	274.6	196.3	296.0	240.3	237.5	165.7	235.5	320.1
OTB	1053.1	1078.3	1329.6	571.5	682.0	651.9	563.9	533.7	405.9	237.0	209.9
PS		17.5									
PTM			0.2								
SB	0.0	0.2									
SV	0.0	0.2									
Overall	**1298.7**	**1271.2**	**1629.1**	**882.34**	**932.14**	**998.64**	**838.99**	**810.23**	**674.85**	**760.34**	**739.97**

Length structures of 2009 and 2010 of GNS were obtained from the adjacent years using the same proportion at length.

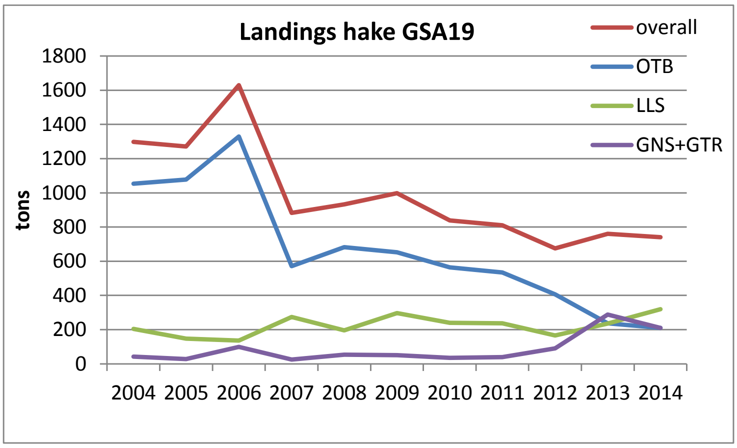


Fig. 5.2.2.5.3.1. Hake in GSA 19. Trend of landings by gear.

The figure 5.2.2.5.3.2 reports the length frequency distributions of the catches (landings+discards). Generally these distributions are dominated by individuals up to 30 cm total length.

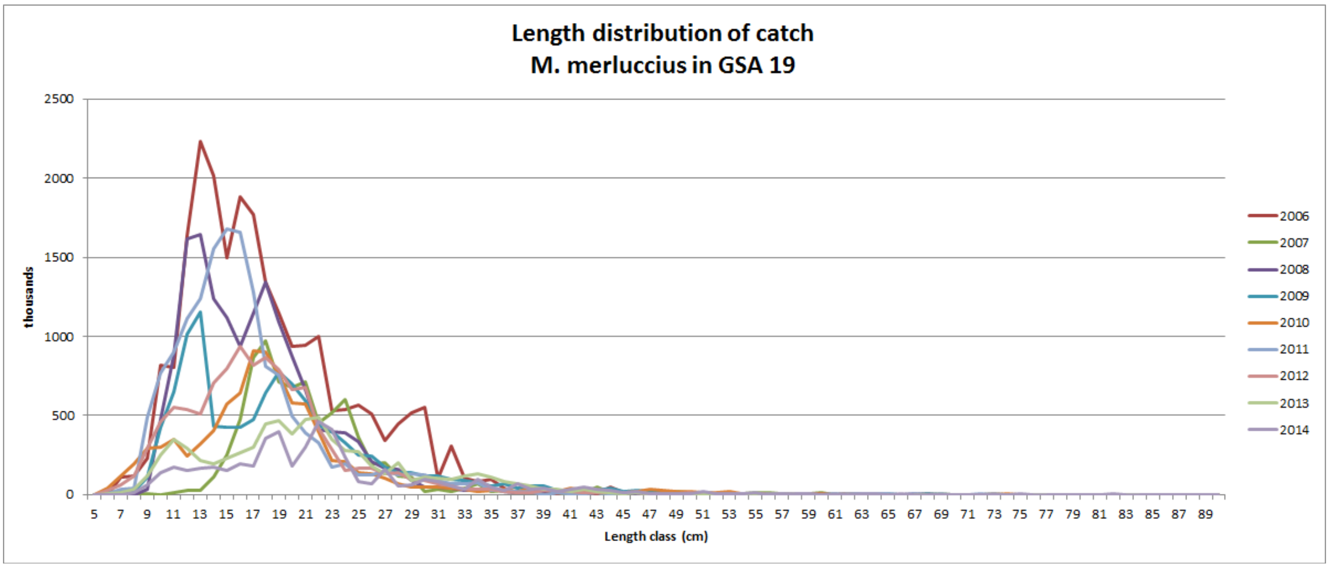


Fig. 5.2.2.5.3.2. Hake in GSA19. Length frequency distribution of catches (landings + discards).

5.2.2.5.4 Discards

Data of discards received by DCF are reported in the table 5.2.2.5.4.1. Discard volume is related to trawlers. It is variable from year to year and about 1-2% of landings.

Table 5.2.2.5.4.1. Hake in GSA 19. Discards from DCF by year, country and gear.

Sum of discards	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
OTB ITA			34.2			53.1	11.0	8.6	11.5	11.5	3.9

Size structure of discards in the missing years (2007 and 2008, as collection of discard data was not foreseen by DCF) was obtained from the following process: 1) the average discard ratio of the time series was applied to the landing of the missing year, 2) the discard volume was then obtained, 3) the discard in numbers by length class was derived by the proportion by length of the time series.

5.2.2.5.5 Fishing effort

The trend in fishing effort by year and major gear type that EWG 15-16 received by DCF is listed in the tables 5.2.2.5.5.1. (nominal effort kw*days) and table 5.2.2.5.5.2 (GT*days). It is also shown in Figure 5.2.2.5.5.1. The recent nominal effort kW*days in the last three years (2011-2014) is decreasing by 12%.

Trawling is generally carried out during daily trips, from Monday to Friday, at different depths, generally from 100 to about 800 m.

Tab. 5.2.2.5.5.1. Hake in GSA 19. Fishing effort, nominal effort kw*days (time series 2004-2014) from DCF.

Nom. effort		year										
country	gear	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
CYP	OTB							3200				
CYP Total								3200				
ITA	-1	1418952	1081525	1776585	1747956	1126093	2427917	3744421	2058250	540335	420069	410146
	FPO	378783	56433	54555	43143	232619	306303	284107	166250	270169	153144	133392

	GND	728507	222428	505277	270396	239342	256486	610146	527523	559590	53176	115664
	GNS	797996	1197159	1402176	1473754	1275650	1441596	1813781	1705748	1627697	2394257	2065333
	GTR	2742293	2115507	1106682	925004	1131865	1653130	1896850	1777574	1590170	3379761	2358945
	LLD	5367540	6420870	4414699	4431347	5603064	3987741	4245026	2453384	3916244	3885256	3835483
	LLS	1143710	861956	870853	1062369	620865	679391	852696	1056634	1307624	2054032	1763634
	LTL		111047	155819	23117	33950				0		
	OTB	5875474	4181999	6770477	5312380	5350926	6361017	6642497	6832229	6382671	6128857	6027003
	OTM								9781	317792		
	PS	1564124	1652286	896924	897398	1452553	791024	765213	741056	1014674	615055	511171
	PTM	0		11424					13898			
Tot. ITA		2E+07	1.8E+07	1.8E+07	1.6E+07	1.7E+07	1.8E+07	2.1E+07	1.7E+07	1.8E+07	1.9E+07	1.7E+07
MLT	LLD											54
Total		2E+07	1.8E+07	1.8E+07	1.6E+07	1.7E+07	1.8E+07	2.1E+07	1.7E+07	1.8E+07	1.9E+07	1.7E+07

Tab. 5.2.2.5.5.2. Hake in GSA 19. Fishing effort, GT*days (time series 2004-2014) from DCF.

Sum gt_days_at_sea	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
-1	**171584**	**133509**	**188462**	**181487**	**127281**	**356898**	**540555**	**292749**	**68756**	**33284**	**39523**
FPO	**11474**	**3134**	**3393**	**2538**	**7528**	**13909**	**8993**	**5670**	**15718**	**12862**	**10551**
GND	**39238**	**26426**	**46130**	**27170**	**20575**	**10122**	**32023**	**27984**	**30215**	**3547**	**12317**
GNS	**78308**	**101868**	**123299**	**123789**	**98544**	**107494**	**134114**	**117849**	**114717**	**183557**	**161938**
DEMSP	78308	99557	123299	122942	96348	106178	130783	115096	108264	142700	143124
SLPF		2311		847	2196	1316	3331	2753	6453	40857	18814
GTR	**233891**	**197023**	**104406**	**88113**	**102936**	**141967**	**149802**	**140997**	**130340**	**243041**	**182299**
LLD	**992388**	**1086458**	**806070**	**804784**	**892144**	**595411**	**583783**	**425801**	**555414**	**684044**	**532179**
LPF	992388	1086458	806070	804784	892144	595411	583783	425801	555414	684044	532179
LLS	**110883**	**69009**	**68640**	**89442**	**64130**	**68039**	**71070**	**101916**	**128798**	**159044**	**151206**
DEMF	110883	69009	68640	89442	64130	68039	71070	101916	128798	159044	151206
LTL		**9999**	**14561**	**1902**	**3598**				**206**		
LPF		9999	14561	1902	3598				206		
OTB	**761067**	**430253**	**672536**	**491942**	**574366**	**711619**	**760317**	**805415**	**785235**	**621952**	**615493**
DEMSP	172918	58896	54251		241580	259945	201051	243988	204367	44112	85357
DWSP			35607	45377	55244	68060	125118	135685	176305	125260	168069
MDDWSP	588149	371357	582678	446565	277542	383614	434148	425742	404563	452580	362067
OTM								**1454**	**43747**		
MDPSP								1454	43747		
PS	**208336**	**190975**	**132197**	**109924**	**184237**	**81658**	**82491**	**111343**	**139663**	**83819**	**75839**
LPF	973	4987	4236	7370	5589	19034	14638	27070	28574	33569	19700
SPF	207363	185988	127961	102554	178648	62624	67853	84273	111089	50250	56139
PTM	**820**		**1478**					**3012**			
SPF	820		1478					3012			
Totale complessivo	**2607989**	**2248654**	**2161172**	**1921091**	**2075339**	**2087117**	**2363148**	**2034190**	**2012809**	**2025150**	**1781345**

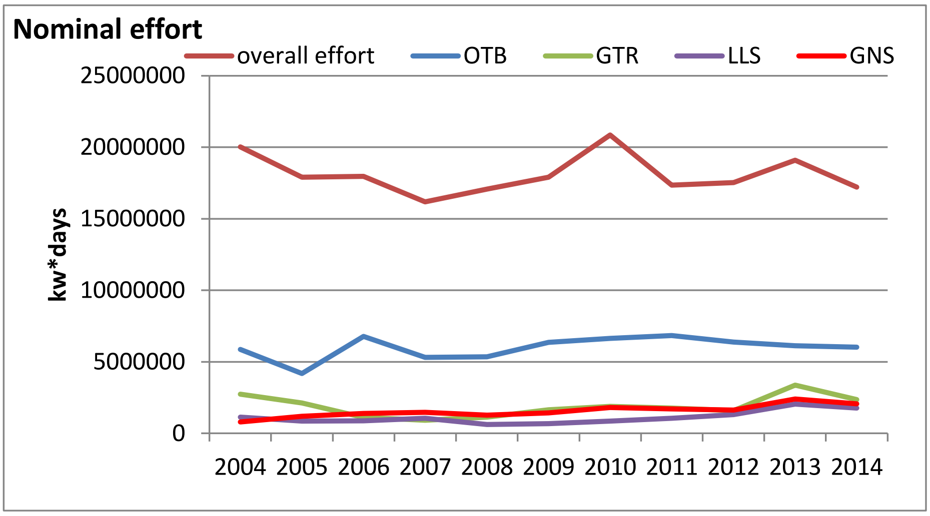


Fig. 5.2.2.5.5.1. Hake in GSA 19. Trend of overall nominal effort in kw*days by fishing technique and overall.

5.2.2.6 Scientific surveys

5.2.2.6.1 Survey #1 (MEDITS)

5.2.2.6.1.1 Methods

According to the MEDITS protocol (Bertrand *et al.*, 2002), trawl surveys were yearly (May-July) carried out, applying a random stratified sampling by depth (5 strata with depth limits at: 50, 100, 200, 500 and 800 m; each haul position randomly selected in small sub-areas and maintained fixed throughout the time). Only in 2014 the survey was shifted in September. Haul allocation was proportional to the stratum area. The same gear (GOC 73, by P.Y. Dremière, IFREMER-Sète), with a 20 mm stretched mesh size in the cod-end, was employed throughout the years. Detailed data on the gear characteristics, operational parameters and performance are reported in Dremière and Fiorentini (1996). Considering the small mesh size a complete retention was assumed. All the abundance data (number of fish per surface unit) were standardized to square kilometer, using the swept area method.

In GSA 19 the following number of hauls was reported per depth stratum (Table 5.2.2.6.1.1.1). Based on the DCF data call, abundance and biomass indices were recalculated.

Table 5.2.2.6.1.1.1. Hake in GSA 19. Number of hauls per year and depth stratum in GSA 19, 1994-2014.

STRATUM	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
10-50	9	9	9	9	9	9	9	9	9	9	9	9	9	8	9	9	9	9	9	9	9
50-100	8	8	8	8	8	8	8	8	8	8	8	8	8	9	8	8	8	8	8	8	8
100-200	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
200-500	15	15	15	15	15	15	15	15	14	14	14	15	14	14	14	14	14	14	14	14	14
500-800	32	32	32	32	32	32	32	32	29	29	29	28	29	29	29	29	29	29	29	29	29
10-800	74	74	74	74	74	74	74	74	70	70	70	70	70	70	70	70	70	70	70	70	70

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Catches by haul were standardized to 60 minutes hauling duration. Hauls noted

as valid were used only, including stations with no catches of hake, red mullet or pink shrimp (zero catches are included).
The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in the GSA:

$$Yst = \Sigma (Yi*Ai) / A$$

$$V(Yst) = \Sigma (Ai^2 * si^2 / ni) / A^2$$

Where:

A=total survey area
Ai=area of the i-th stratum
si=standard deviation of the i-th stratum
ni=number of valid hauls of the i-th stratum
n=number of hauls in the GSA
Yi=mean of the i-th stratum
Yst=stratified mean abundance
V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as ± standard deviation.
It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution, quasi-poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial (e.g. O'Brien *et al*. 2004).
Length distributions represented an aggregation (sum) of standardized length frequencies distribution raised to standardized haul abundance per square km over the stations of each stratum.

Figure 5.2.2.1.6.1. Hake in GSA 19. Localization of hauls in Medits survey.

5.2.2.6.1.2 Geographical distribution

The geographical distribution pattern of European hake has been studied in the area using trawl-survey data.

Recently in the STOCKMED project (MAREA Framework; Fiorentino et al., 2015) biomass trends (average of the last 10 years) have been estimated by GFCM statistical rectangle (Figure 5.2.2.6.1.2.1.).

If recruits are considered, the higher concentration in the GSA 19 was found between Otranto and Santa Maria di Leuca, around the Amendolara Bank and from Siracusa to Cape Passero on bottom grounds down to 200 m depth, in accordance with Carlucci et al. (2009). Persistence of the nursery areas along the time was estimated from the indicator kriging in MEDISEH project (MAREA Framework; Giannoulaki et al., 2013; Colloca et al., 2015) (Figure 5.2.2.6.1.2.2.).

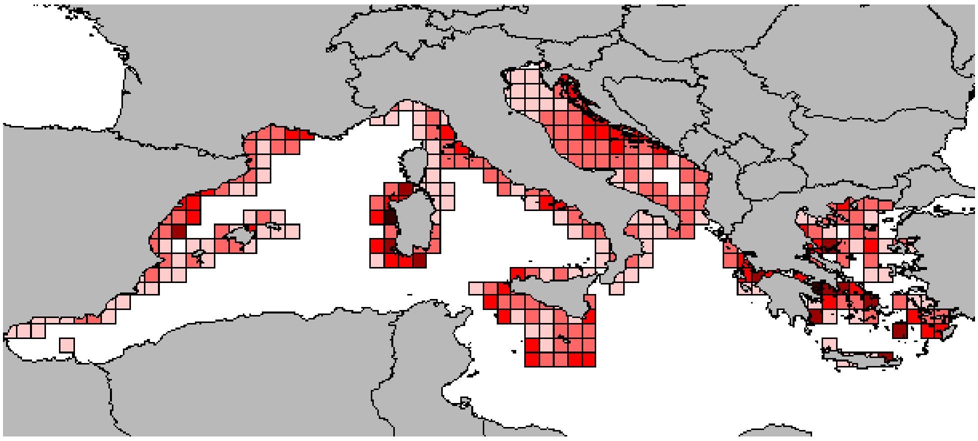


Figure 5.2.2.6.1.2.1. Geographical distribution of hake in the Mediterranean basin by StockMed project (MAREA Framework).

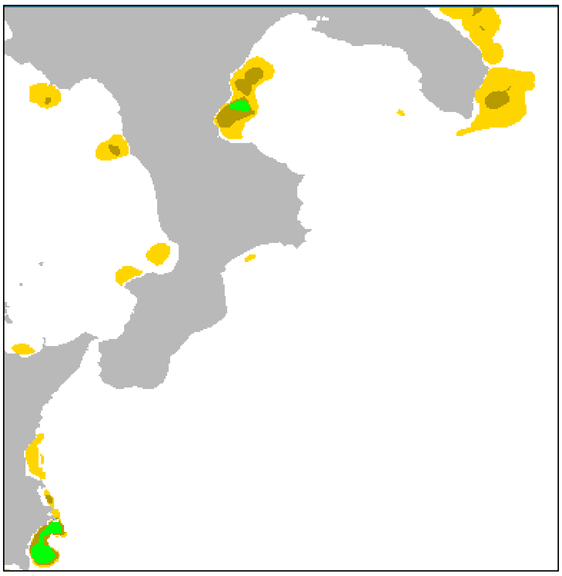


Figure 5.2.2.6.1.2.2. Hake in GSA 19. Persistent nursery areas.

5.2.2.6.1.3 Trends in abundance and biomass

Fishery independent information regarding the state of the hake in GSA 19 was derived from the international survey MEDITS. Figure 5.2.2.6.1.3.1. displays the estimated trend of hake abundance and biomass indices standardized to the surface unit in the GSA19. Indices from MEDITS trawl-surveys show an increasing pattern from 2004, although variability is very high with remarkable peaks of abundance in 2004, 2008 and 2012. The value of 2014 are lower compared to these peaks (Figure 5.2.2.6.1.3.1.). Estimates of abundance indices (N/km^2 and kg/km^2) from MEDITS time series (1994-2014) with coefficient of variation and depth range are reportedin the table 5.2.2.6.1.3.1.

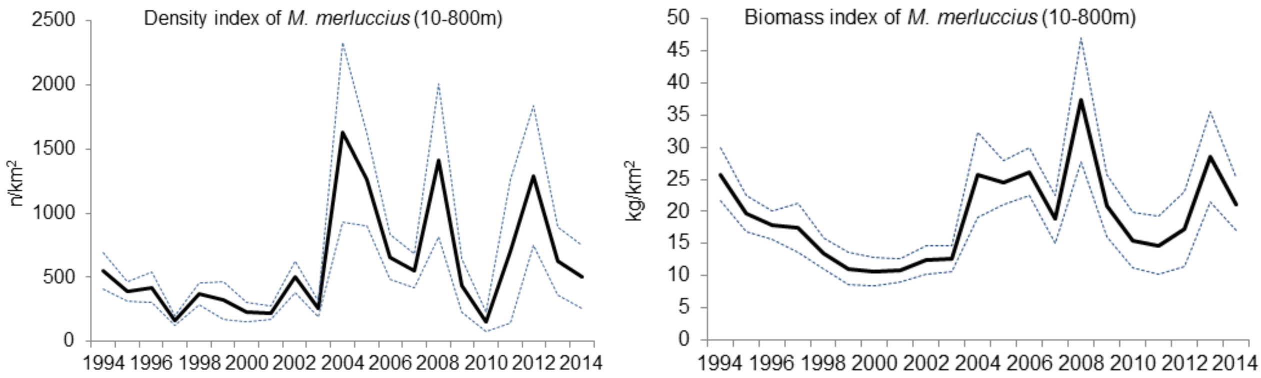


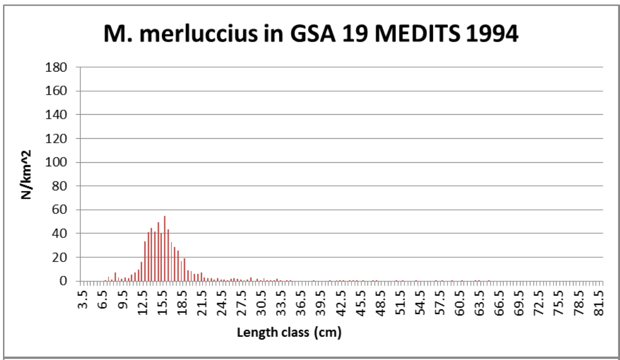
Figure 5.2.2.6.1.3.1. Hake in GSA 19. Trends of density and biomass.

Table 5.2.2.6.1.3.1. Hake in GSA 19. Abundance indices (N/km^2 and kg/km^2) from MEDITS time series (1994-2014) with coefficient of variation and depth range of the estimates.

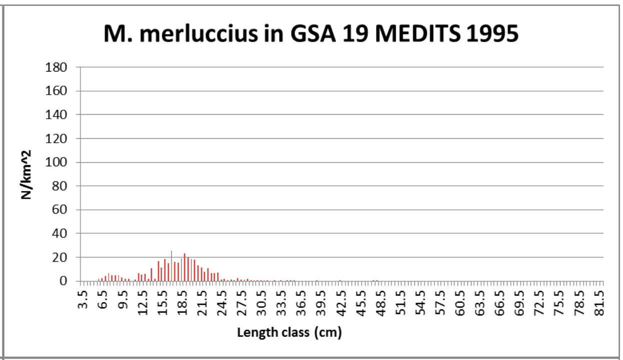
Survey	Area	Species	Depth Min	Depth Max	N/km^2	CV (%)	kg/km^2	CV (%)
MEDITS 1994	19	MERL MER	10	800	623	26.08	27.74	15.99
MEDITS 1995	19	MERL MER	10	800	373	25.75	19.91	20.94
MEDITS 1996	19	MERL MER	10	800	421	28.49	17.85	12.34
MEDITS 1997	19	MERL MER	10	800	160	23.88	17.46	22.04
MEDITS 1998	19	MERL MER	10	800	369	22.94	13.42	17.78
MEDITS 1999	19	MERL MER	10	800	321	46.18	11.05	22.76
MEDITS 2000	19	MERL MER	10	800	269	41.51	8.99	28.10
MEDITS 2001	19	MERL MER	10	800	256	24.13	11.67	17.86
MEDITS 2002	19	MERL MER	10	800	505	24.47	12.38	18.00
MEDITS 2003	19	MERL MER	10	800	255	23.00	12.76	15.28
MEDITS 2004	19	MERL MER	10	800	1645	42.93	25.86	25.86
MEDITS 2005	19	MERL MER	10	800	1249	28.48	24.05	13.86
MEDITS 2006	19	MERL MER	10	800	659	26.19	26.13	14.19
MEDITS 2007	19	MERL MER	10	800	550	23.76	18.79	20.12
MEDITS 2008	19	MERL MER	10	800	1411	42.38	37.31	25.66
MEDITS 2009	19	MERL MER	10	800	436	47.15	20.86	23.25
MEDITS 2010	19	MERL MER	10	800	154	47.26	15.50	27.88
MEDITS 2011	19	MERL MER	10	800	702	79.61	14.74	30.54
MEDITS-2012	19	MERL MER	10	800	1294	42.12	17.26	33.15
MEDITS-2013	19	MERL MER	10	800	628	42.74	28.51	24.59
MEDITS-2014	19	MERL MER	10	800	503	49.51	21.18	19.83

5.2.2.6.1.4 Trends in abundance by length or age

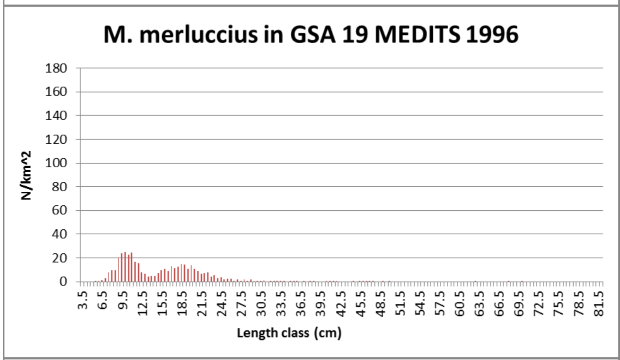
Figure 5.2.2.6.1.4.1. shows trend of length frequency distributions obtained by MEDITS trawl survey. Remarkable peaks of recruitment are observed in 2004-2005; 2008 and 2012.



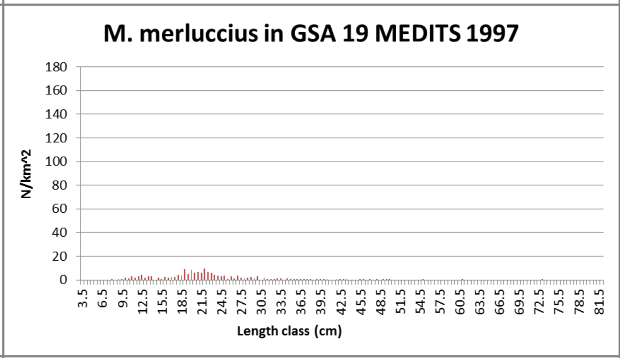
M. merluccius in GSA 19 MEDITS 1994
N/km^2
Length class (cm)



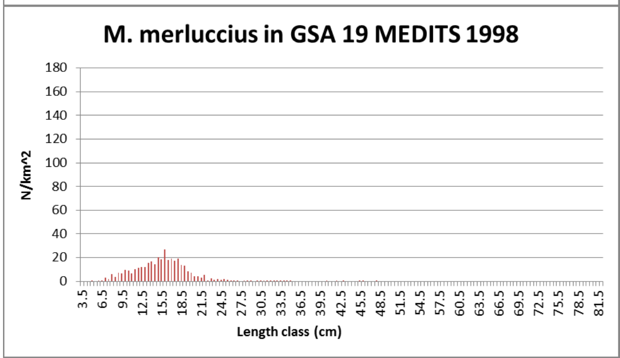
M. merluccius in GSA 19 MEDITS 1995
N/km^2
Length class (cm)



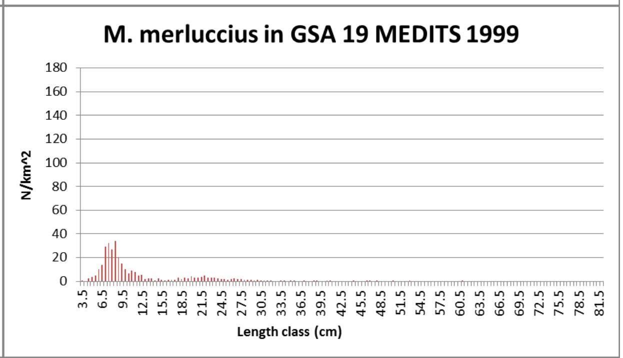
M. merluccius in GSA 19 MEDITS 1996
N/km^2
Length class (cm)



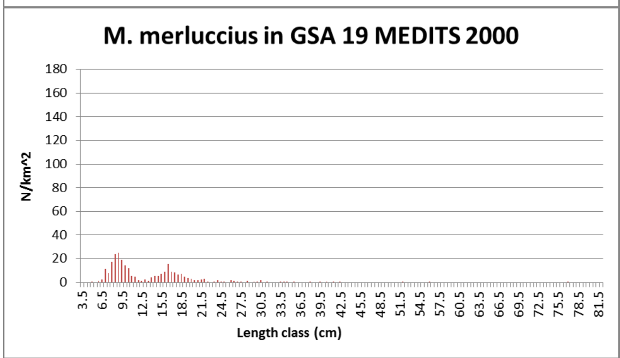
M. merluccius in GSA 19 MEDITS 1997
N/km^2
Length class (cm)



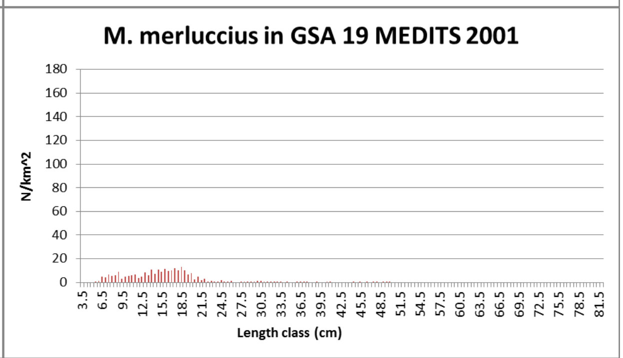
M. merluccius in GSA 19 MEDITS 1998
N/km^2
Length class (cm)



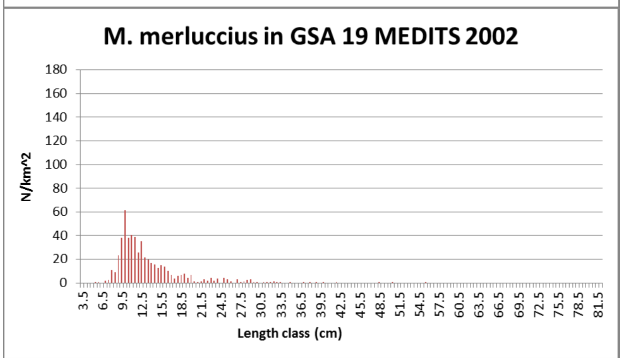
M. merluccius in GSA 19 MEDITS 1999
N/km^2
Length class (cm)



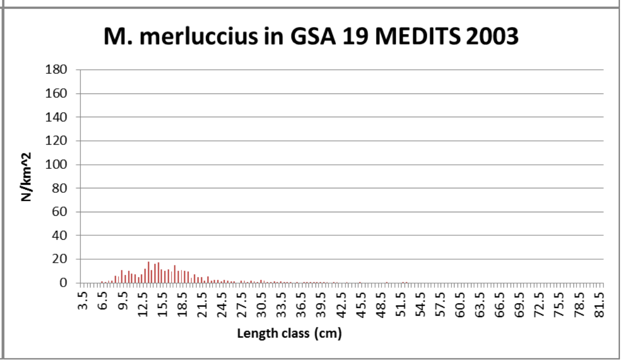
M. merluccius in GSA 19 MEDITS 2000
N/km^2
Length class (cm)



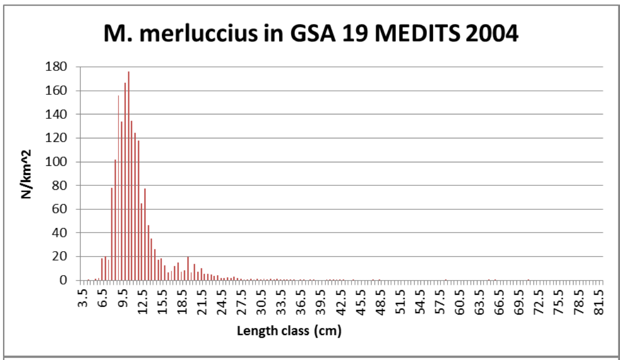
M. merluccius in GSA 19 MEDITS 2001
N/km^2
Length class (cm)

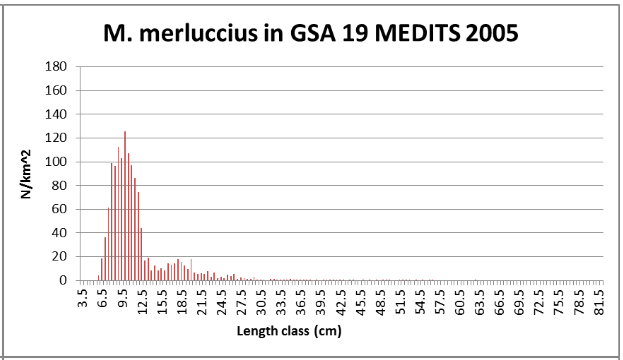


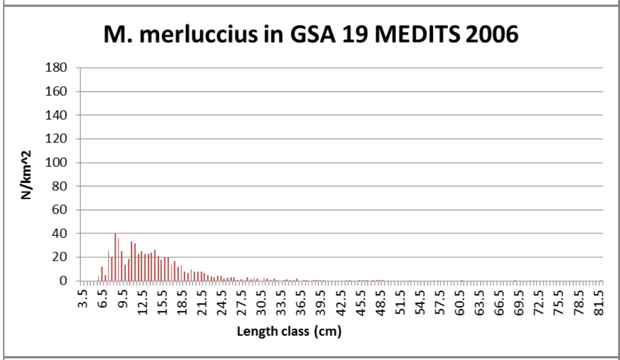
M. merluccius in GSA 19 MEDITS 2002
N/km^2
Length class (cm)

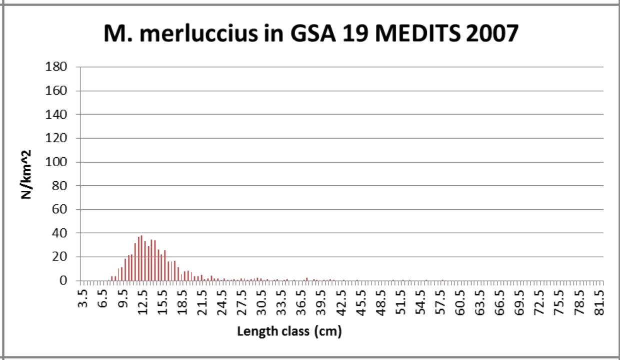


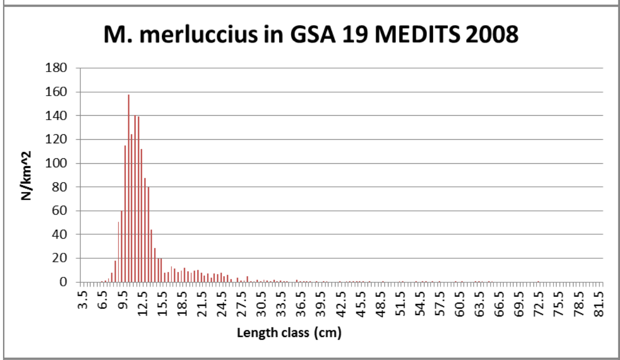
M. merluccius in GSA 19 MEDITS 2003
N/km^2
Length class (cm)

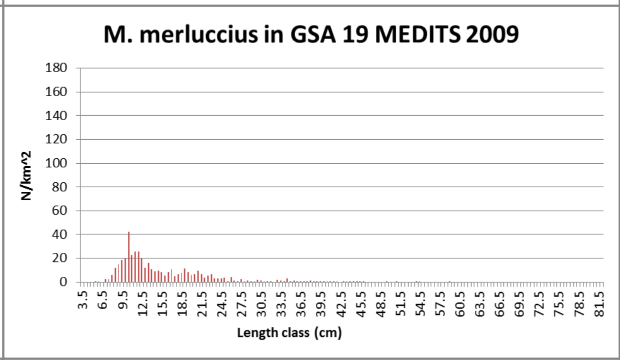

M. merluccius in GSA 19 MEDITS 2004
N/km^2
Length class (cm)

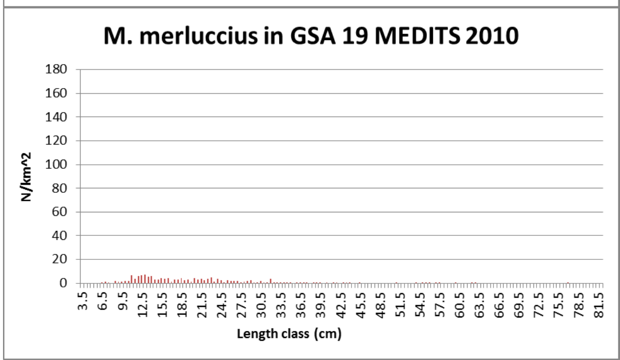

M. merluccius in GSA 19 MEDITS 2005
N/km^2
Length class (cm)

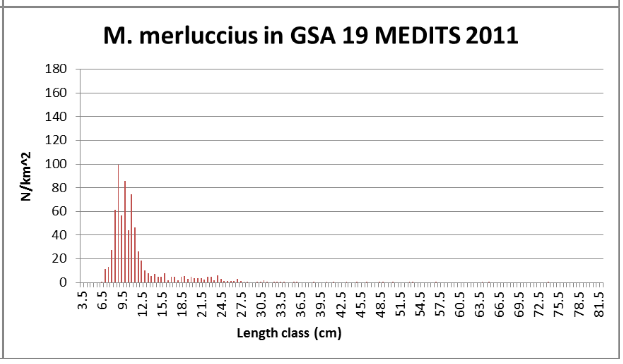

M. merluccius in GSA 19 MEDITS 2006
N/km^2
Length class (cm)


M. merluccius in GSA 19 MEDITS 2007
N/km^2
Length class (cm)


M. merluccius in GSA 19 MEDITS 2008
N/km^2
Length class (cm)


M. merluccius in GSA 19 MEDITS 2009
N/km^2
Length class (cm)


M. merluccius in GSA 19 MEDITS 2010
N/km^2
Length class (cm)


M. merluccius in GSA 19 MEDITS 2011
N/km^2
Length class (cm)

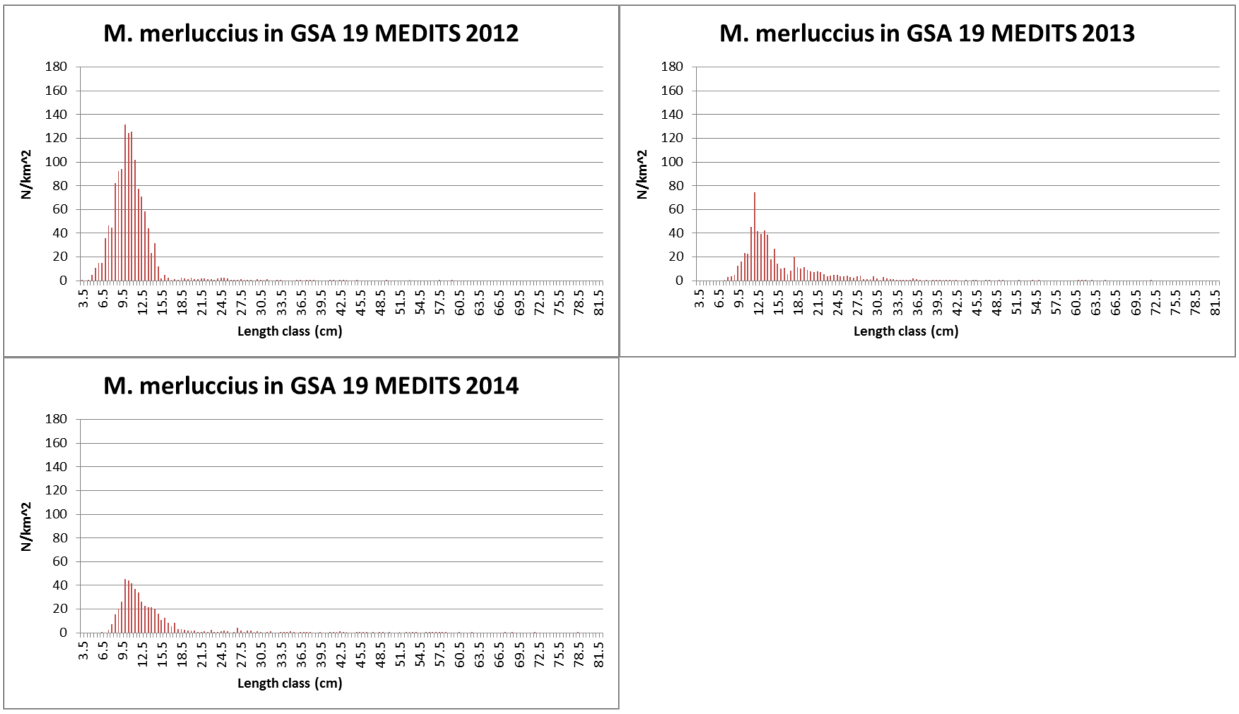


Figure 5.2.2.6.1.4.1. Hake in GSA 19. Trends Length frequency distributions by MEDITS trawl survey.

5.2.2.7 Stock Assessment

5.2.2.7.1 Methods

The Extended Survivors Analysis (XSA – Darby and Flatman, 1994) has been used with an age range from 0 to 4+. Discard was included in the analysis. Since no discard data were available for 2007 and 2008, an estimate based on the length structures of the previous and following years has been done. Age structure of GNS in 2009 and 2010 has been estimated as average of contiguous years.

5.2.2.7.2 Input data

For the assessment of hake in GSA 19 the DCF official data on the length structure has been used: no SOP correction has been applied as differences were far less than 10%. The age distribution has been estimated using the knife-edge slicing method (LFDA algorithm) with the growth parameters used in the past assessment. A sex-combined analysis was carried out.
The survey indices from MEDITS data from 2006 to 2014 have been used for the tuning
The age distribution of catches is showed in the table 5.2.2.7.2.1. and in the figure 5.2.2.7.2.1. Age class 0 is more abundant in 2006, 2008 and 2011. The age distribution of the tuning indices (MEDITS) is reported in the table 5.2.2.7.2.2. and in the figure 5.2.2.7.2.2. Age 0 is more abundant in 2008 and 2012. The number of age classes well represented in the catches is generally low.

Table 5.2.2.7.2.1. Hake in GSA 19. Catch-at-age data by year used in the assessment.

	Catch-at-age (thousands)								
Age class	2006	2007	2008	2009	2010	2011	2012	2013	2014
0	11663	2775	10486	1986	3967	10886	5331	1665	1399
1	8569	4812	4931	4628	3379	3384	3920	3860	2744

2	344	213	213	486	306	180	209	517	433
3	44	102	53	94	164	61	46	22	81
4+	26	37	32	23	28	30	9	14	45

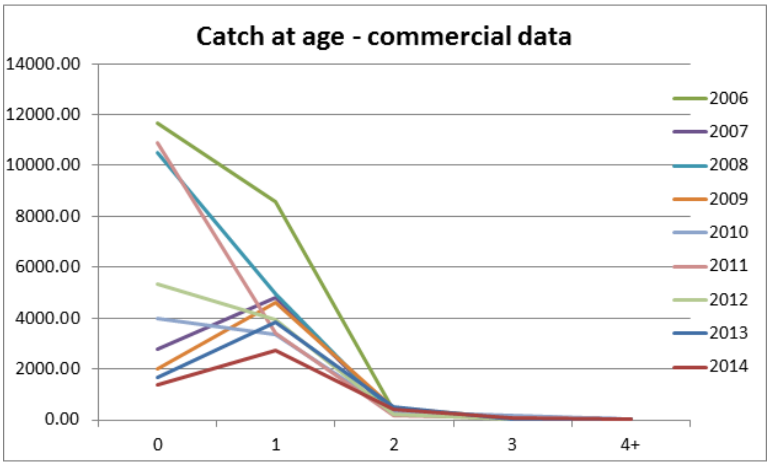


Figure 5.2.2.7.2.1. Hake in GSA 19. Catch-at-age data by year used in the assessment.

Table 5.2.2.7.2.2. Hake in GSA 19. Tuning data by age and year from MEDITS survey.

	Catch-at-age (N/km^2)								
Age class	2006	2007	2008	2009	2010	2011	2012	2013	2014
0	516	459	1254	312	77	628	1257	465	451
1	128	81	146	110	69	69	34	152	39
2	9	9	8	13	5	3	3	10	8
3+	2.2	0.5	1.5	1.1	1.2	1.2	0.3	1.0	3.1

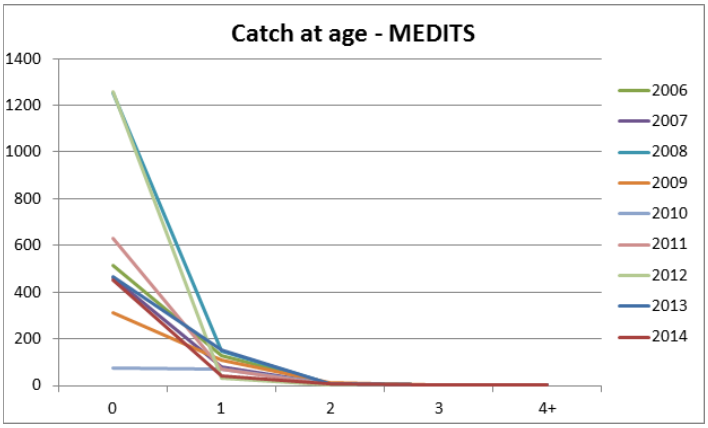


Figure 5.2.2.7.2.2. Hake in GSA 19. Tuning data by MEDITS survey.

Tables 5.2.2.7.2.3-4. report the individual weight used as inputs to the model, respectively for the commercial catches and the stock, while table 5.2.2.7.2.5. reports the vector of maturity and natural mortality used in the assessment. As regards maturity a vector was used instead of a matrix given the negligible variation of the maturity ogives along the time series.

Table 5.2.2.7.2.3. Hake in GSA 19. Individual weight in the catches.

	0	1	2	3	4+
2006	0.023987	0.111359	0.454918	1.110828	2.323314
2007	0.033493	0.091433	0.514531	1.107712	2.201705
2008	0.021636	0.086723	0.473423	1.139353	2.241689
2009	0.032007	0.100881	0.490912	1.088541	2.183864
2010	0.028605	0.085525	0.509774	1.056449	2.114163
2011	0.021364	0.102426	0.475292	1.152765	2.241269
2012	0.025515	0.090365	0.490984	1.030116	1.675208
2013	0.028519	0.111818	0.432579	0.978035	1.955024
2014	0.02679	0.105753	0.49462	1.122436	2.576023

Table 5.2.2.7.2.4. Hake in GSA 19. Individual weight in the stock.

	0	1	2	3	4+
2006	0.005553	0.136502	0.518743	1.140896	2.814516
2007	0.005553	0.136502	0.518743	1.140896	2.814516
2008	0.005553	0.136502	0.518743	1.140896	2.814516
2009	0.005553	0.136502	0.518743	1.140896	2.814516
2010	0.005553	0.136502	0.518743	1.140896	2.814516
2011	0.005553	0.136502	0.518743	1.140896	2.814516
2012	0.005553	0.136502	0.518743	1.140896	2.814516
2013	0.005553	0.136502	0.518743	1.140896	2.814516
2014	0.005553	0.136502	0.518743	1.140896	2.814516

Table 5.2.2.7.2.5. Hake in GSA 19. Vectors of proportion of mature and natural mortality at age.

Age	Proportion of matures	Natural mortality at age
0	0	1.16
1	0.2	0.53
2	0.9	0.4
3	1	0.35
4+	1	0.32

5.2.2.7.3 Results

The XSA run with the following settings has been performed:
- Catchability (rage) independent on stock size for all ages =0.
- Catchability (qage) independent of age for ages >= 4.
- Minimum standard error for population estimates derived from each fleet = 0.300.
- shk.n=TRUE, shk.f=TRUE, shk.yrs=3, shk.ages=2
- Natural and Fishing mortality before spawning = 0

A sensitivity analysis has been performed with S.E. of the mean to which the estimates are shrunk equal to 0.5, 1, 1.5 and 2 (Fig. 5.2.2.7.3.1.). The minimum, maximum and average residuals by shrinkage are reported in the table 5.2.2.7.3.1.

The run with shrinkage 2 has been chosen on the basis of the residuals and of the retrospective analysis.

- Shrinkage of the mean (fse): 2.

The log-catchability residuals at age and the retrospective analysis results are shown in figure 5.2.2.7.3.2-3.

The stock overview is reported in the figure 5.2.2.7.3.4.

Tab. 5.2.2.7.3.1. Hake in GSA 19. Residuals (minimum, maximum and average) by shrinkage.

shrinkage	minimum	maximum	average
0.5	-1.262	1.322	0.423
1	-1.162	1.234	0.367
1.5	-1.220	0.464	0.247
2	-1.236	0.456	0.240

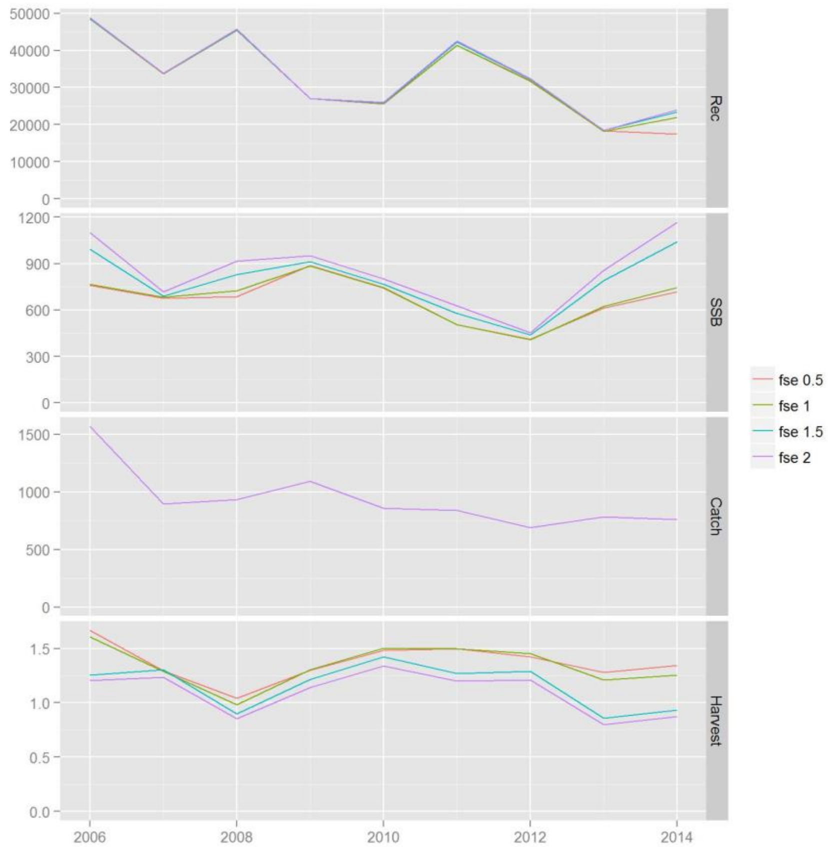


Fig. 5.2.2.7.3.1. Hake in GSA 19. Sensitivity analysis.

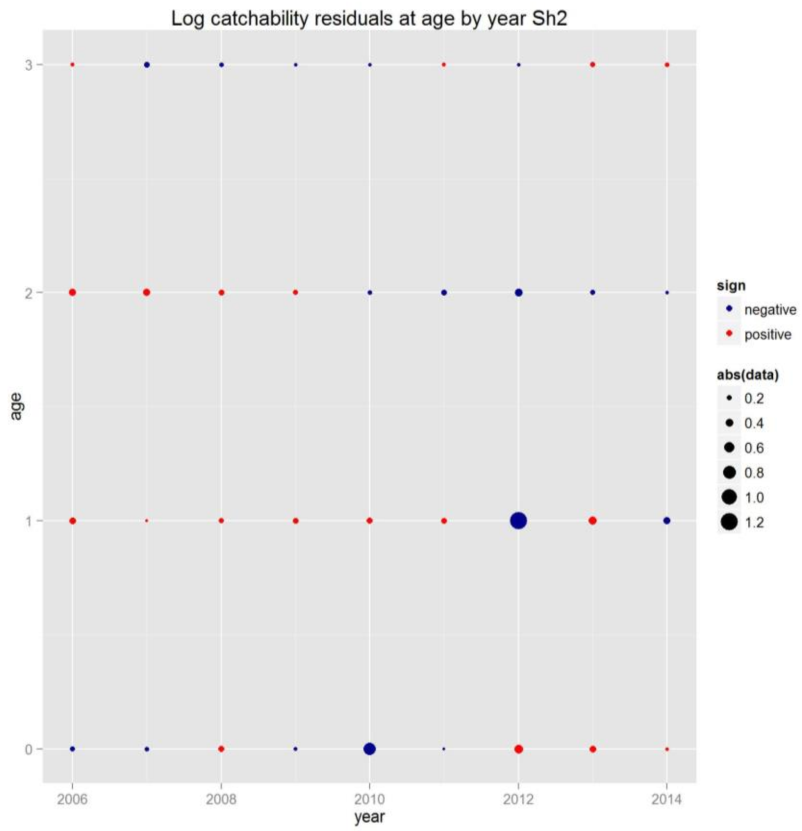


Fig. 5.2.2.7.3.2. Hake in GSA 19. Map of the residuals with shrinkage 2.

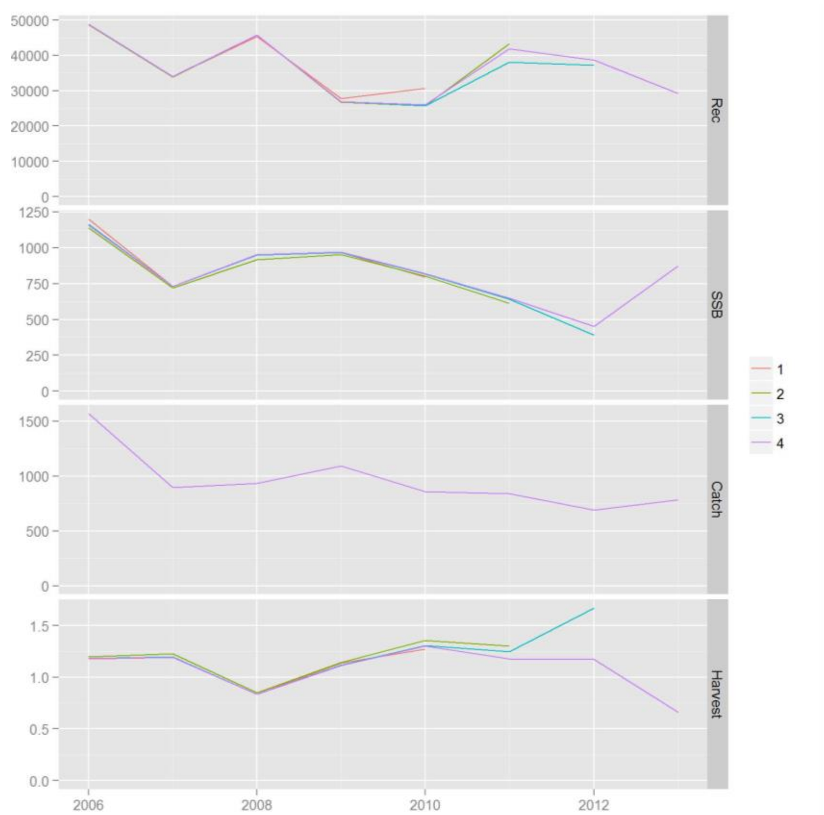


Fig. 5.2.2.7.3.3. Hake in GSA 19. Retrospective analysis (shrinkage 2).

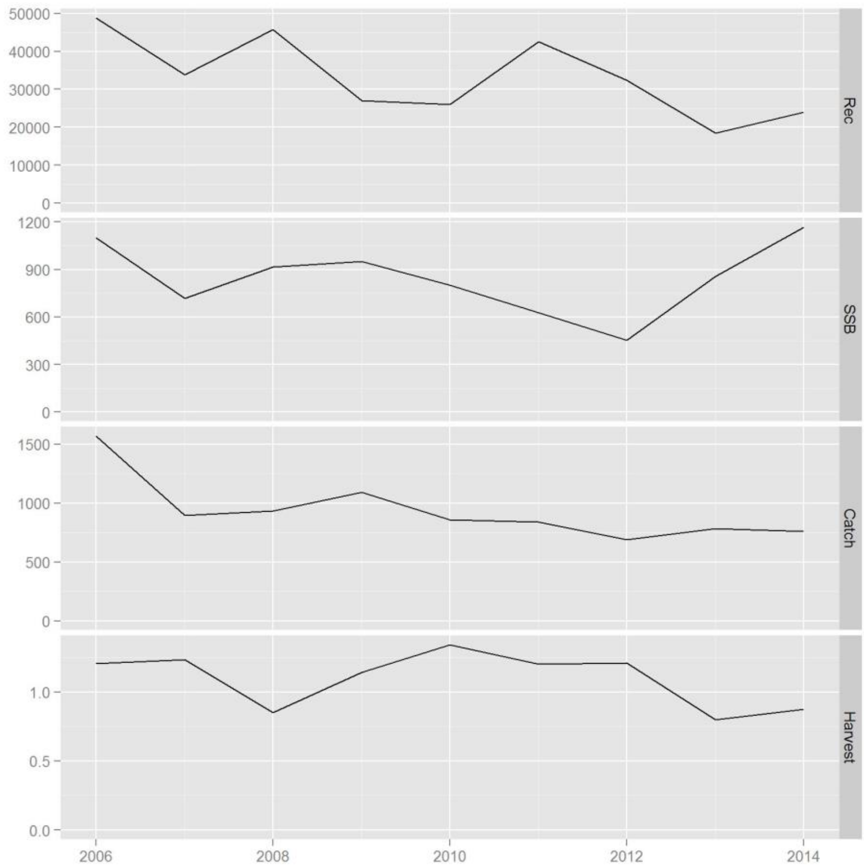


Fig. 5.2.2.7.3.4. Hake in GSA 19. XSA stock summary.

Tables 5.2.2.7.3.2. and 5.2.2.7.3.3. report respectively the fishing mortality at age by year and the value of average fishing mortality (Fbar) between age 0 to 3 by year. The model outputs related to the Recruitment and the Spawning Stock Biomass by year are reported in the tables 5.2.2.7.3.4. and 5.2.2.7.3.5.

Tab. 5.2.2.7.3.2. Hake in GSA 19. F at age.

age	2006	2007	2008	2009	2010	2011	2012	2013	2014
0	0.76	0.27	0.67	0.49	0.46	0.67	0.46	0.31	0.14
1	2.63	2.09	1.56	1.97	2.22	2.09	1.37	1.55	1.82
2	1.08	0.72	0.70	0.99	1.08	1.23	1.13	0.96	1.08
3	0.34	1.85	0.47	1.11	1.60	0.82	1.87	0.38	0.46
4+	0.34	1.85	0.47	1.11	1.60	0.82	1.87	0.38	0.46

Tab. 5.2.2.7.3.3. Hake in GSA 19. Fbar 0-3.

2006	2007	2008	2009	2010	2011	2012	2013	2014
1.21	1.23	0.85	1.14	1.34	1.20	1.21	0.80	0.87

Tab. 5.2.2.7.3.4. Hake in GSA 19. Recruitment.

2006	2007	2008	2009	2010	2011	2012	2013	2014
48759	33912	45754	26960	26017	42583	32369	18516	23895

Tab. 5.2.2.7.3.5. Hake in GSA 19. SSB.

2006	2007	2008	2009	2010	2011	2012	2013	2014
1101	717	914	952	800	626	452	856	1167

5.2.2.8 Reference points Reference points

5.2.2.8.1 Methods

To predict the effect of changes in fishing mortality on future yields and to define reference points $F_{0.1}$ (as a proxy for F_{MSY}) and F_{max} a Yield per Recruit analysis (YPR) was carried out in R.

5.2.2.8.2 Input data

As input the same population parameters used for the XSA and its output of the exploitation pattern were used.

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5.2.2.8.3 Results

The reference points obtained with shrinkage 2 are shown in table 5.2.2.8.3.1., while the curve of the yield per recruit in figure 5.2.2.8.3.1.

Tab. 5.2.2.8.3.1. Hake in GSA 19. Reference points at $F_{0.1}$ (shrinkage 2).

Ref. point	F	Total Yield	Recruitment	SSB	Biomass
$F_{0.1}$	0.18	1704	31704	14529	16038

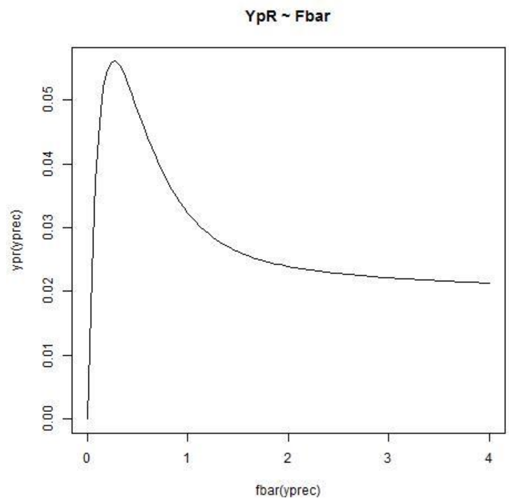


Fig. 5.2.2.8.3.1. Hake in GSA 19. Yield per recruit curve.

5.2.2.9 Data quality

Data from DCF 2015 were used. A difference in the sum of products compared to landings was always far less than 10%. Discards data of 2006, 2009, 2010, 2011, 2012, 2013 and 2014 were available. Information on number of samples for landings, discards and catches, as well as the

number of measurements by length for landings, discards and catches were also available. Number of otoliths was also available. MEDITS raw data used for this assessment have been processed by the expert using the software FishTrawl. Biological parameters by length and age and sex ratio were available for the whole time series (2002-2014).
In 2014 the survey was shifted in September as a consequence of the administrative process undertaken Italian Ministry of Agriculture.

5.2.2.10 Short term predictions 2016-2018

5.2.2.10.1 Method

A deterministic short term prediction for the period 2015 to 2017 was performed using the FLR routines provided by JRC, which takes into account the catch and landings in numbers and weight and the discards. This routine performs short terms for the whole fleet.
A generic approximate multifleet projections with FLR provided by JRC was also used to split the fishing mortality by fleet using proportion of catch in number by age and fleet.

5.2.2.10.2 Input parameters

The same input parameters used in the XSA analysis shown above were used. Different scenarios of constant harvest strategy with F_{bar} calculated as the average of ages 0 to 3 and F status quo (F_{stq} = 0.95; geometric mean of the last three years) were performed. Recruitment (class 0) has been estimated from the population results as geometric mean of the last three years 2012-2014 (24284 thousands individuals) estimated using XSA.

5.2.2.10.3 Results

The results of the short term forecasts related to the whole fleet are summarised in the table Table 5.2.2.10.3.1. and in the figure 5.2.2.10.3.1.

Table 5.2.2.10.3.1. Hake in GSA 19. Short term forecast in different F scenarios. Basis: F(2015) = mean (F_{bar}0-3 2012-2014)= 0.94; R(2015) = geometric mean of the recruitment of the last 3years; R = 24284 (thousands); SSB(2014) = 1167 t, Catch (2014)= 759 t.

Rationale	Ffactor	fbar	Catch 2016	Catch 2017	SSB 2017	Change SSB 2016-2017 (%)	Change Catch 2014-2016 (%)
zero catch	0	0.000	0	0	2707	195	-100
High long-term yield (F0.1)	0.19	0.18	240	443	2137	132.7	-68.3
Status quo	1	0.95	857	830	846	-7.8	13.0
Different scenarios	0.1	0.09	131	264	2392	160.6	-82.7
	0.2	0.19	249	456	2117	130.6	-67.2
	0.3	0.28	355	594	1877	104.4	-53.3
	0.4	0.38	450	690	1666	81.5	-40.7
	0.5	0.47	535	755	1482	61.4	-29.4

	0.6	0.57	613	797	1320	43.7	-19.2
	0.7	0.66	683	821	1178	28.3	-9.9
	0.8	0.76	747	833	1053	14.7	-1.6
	0.9	0.85	805	835	943	2.7	6.1
	1.1	1.04	906	821	761	-17.1	19.4
	1.2	1.14	950	808	686	-25.3	25.2
	1.3	1.23	990	794	619	-32.6	30.5
	1.4	1.32	1027	778	560	-39.0	35.4
	1.5	1.42	1062	762	508	-44.7	40.0
	1.6	1.51	1093	746	461	-49.8	44.1
	1.7	1.61	1123	730	420	-54.3	48.0
	1.8	1.70	1150	714	383	-58.3	51.6
	1.9	1.80	1175	699	350	-61.8	54.9
	2	1.89	1199	685	321	-65.0	58.0

A short term projection of the whole fleet (table 5.2.2.10.3.1.), assuming an Fstq of 0.95 in 2014 (geometric mean of last three years) and a recruitment of 24284 (thousands) individuals (geometric mean of last three years) shows that:

- Fishing at the Fstq (0.95) generates an increase of the catch of 13% from 2014 to 2016 along with a decrease of spawning stock biomass (change -7.8%) from 2016 to 2017.
- Fishing at F0.1 (0.18) generates a decrease of the catch of 68.3% from 2014 to 2016 and an increase of spawning stock biomass of 132.7% from 2016 to 2017.

Results of the short term multifleet projections are reported in the tables 5.2.2.10.3.2-3. and Figure 5.2.2.10.3.1. Table 5.2.2.10.3.2. shows the values of the fishing mortality split by year and fishing technique, while table 5.2.2.10.3.3. shows the level of catches by fishing technique for the two selected scenarios: status quo and $F_{0.1}$.

Table 5.2.2.10.3.2. Hake in GSA 19. Fbar by year and gear.

Fbar 0-3	2006	2007	2008	2009	2010	2011	2012	2013	2014	Mean of last three years
trawl	0.98	0.64	0.59	0.77	0.95	0.75	0.58	0.28	0.29	0.38
nets	0.07	0.05	0.06	0.05	0.05	0.06	0.09	0.28	0.33	0.23
lls	0.15	0.54	0.20	0.33	0.34	0.39	0.54	0.24	0.25	0.34
overall	1.21	1.23	0.85	1.14	1.34	1.20	1.21	0.80	0.87	0.96

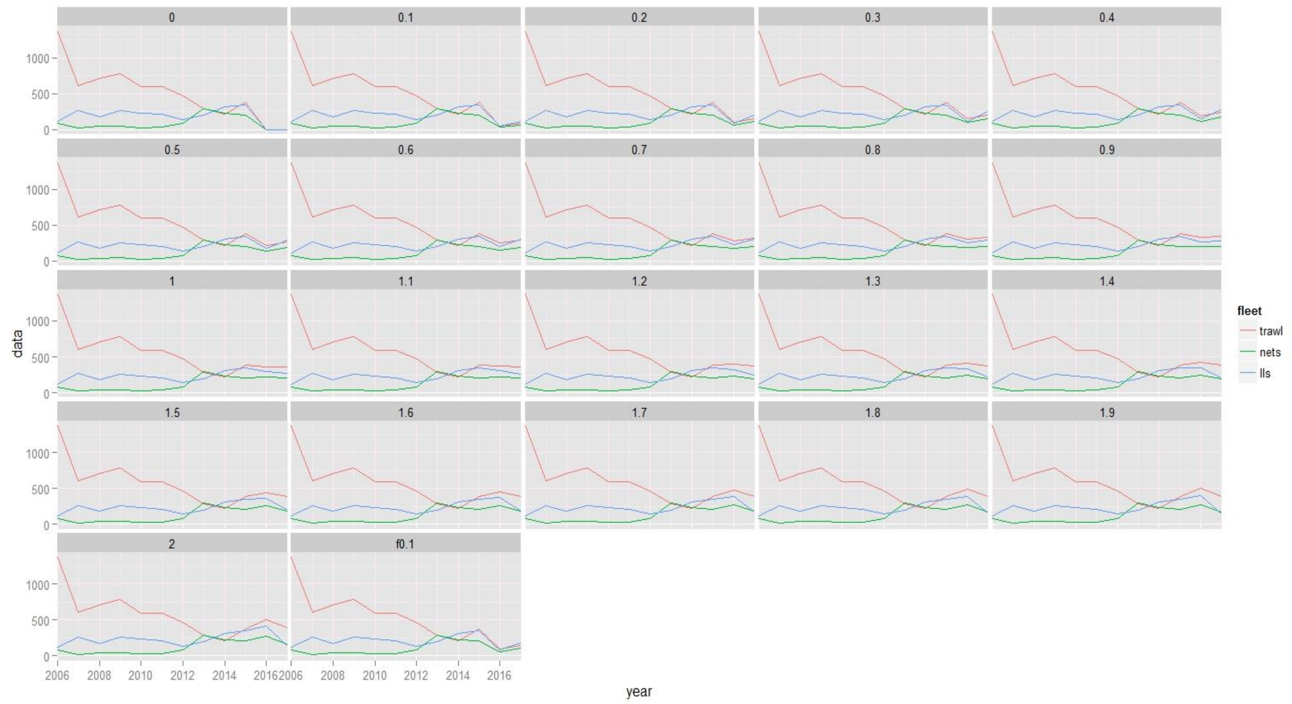


Fig. 5.2.2.10.3.1. Hake in GSA 19. Results of the short term multifleet projections for different scenarios (status quo=1).

Table 5.2.2.10.3.3. Hake in GSA 19. Short term forecast scenarios (status quo=1; and $F_{0.1}$) by fleet.

fleet	age	year	Catches	qname	fleet	age	year	data	qname	fleet	age	year	data	qname
trawl	all	2015	383.12	1	nets	all	2015	205.44	1	lls	all	2015	346.88	1
trawl	all	2016	353.63	1	nets	all	2016	212.63	1	lls	all	2016	291.23	1
trawl	all	2017	355.8	1	nets	all	2017	204.85	1	lls	all	2017	269.35	1
trawl	all	2015	383.12	f0.1	nets	all	2015	205.44	f0.1	lls	all	2015	346.88	f0.1
trawl	all	2016	98.178	f0.1	nets	all	2016	63.499	f0.1	lls	all	2016	78.719	f0.1
trawl	all	2017	142.25	f0.1	nets	all	2017	109.58	f0.1	lls	all	2017	191.37	f0.1

5.2.2.11 Medium term predictions

Medium term was not conducted because no meaningful stock-recruitment relationship was estimated.

5.2.2.11.1 Method

5.2.2.12 Stock advice

STECF-EWG 15-16 proposes F_{MSY}=0.18 as limit management reference point consistent with high long term yield and lower risk of stock collapse.

After a decreasing pattern SSB showed an increasing trend in the last two years while recruitment only in the last year. Also F was decreasing in the last two years. According to the F estimates obtained using landing, discard data and survey indices in XSA, in the last year of the time series (2014) Fcurr (0.87) was above the estimated reference value of F_{MSY}=0.18.

The $F_{current}$ is equal to 0.87. This value is larger than $F_{0.1}$ (0.18), chosen as proxy of F_{MSY} and as the exploitation reference point consistent with long term yields (F_{MSY}), which indicates that the stock of hake in GSA 19 is being fished above F_{MSY}. Catches of hake in 2016 consistent with $F_{0.1}$ (0.16) should not exceed 1813 tonnes.

5.2.2.13 Management strategy evaluations

The F_{MSY} ranges were derived using the formula provided by STECF 15-09:

F_{upper}=0.007802+1.349402*F_{MSY}
F_{lower}=0.002966+0.660214*F_{MSY}

F ranges results were F_{lower} (0.12), F_{upper} (0.25), B_{lim} (452 t) was estimated as the minimum SSB estimated in XSA assessment. A Management Strategy Evaluation was conducted with an FLR script distributed at EWG 15-11. The Management Strategy Evaluation was ran to evaluate if the MSY ranges were precautionary. The Management Strategy Evaluation included uncertainty in the recruitment around a mean level resulting from the geometric mean of the last 3 years of data and uncertainty in the MEDITS CPUE tuning fleet indices. The stock was assessed by XSA, with the same settings of the assessment at each iteration. The number of iterations was 250. The following figure 5.2.2.13.1. shows the evolution of the main four stock indicators. The probability of SSB falling below B_{lim} at F_{upper} was estimated at 0.

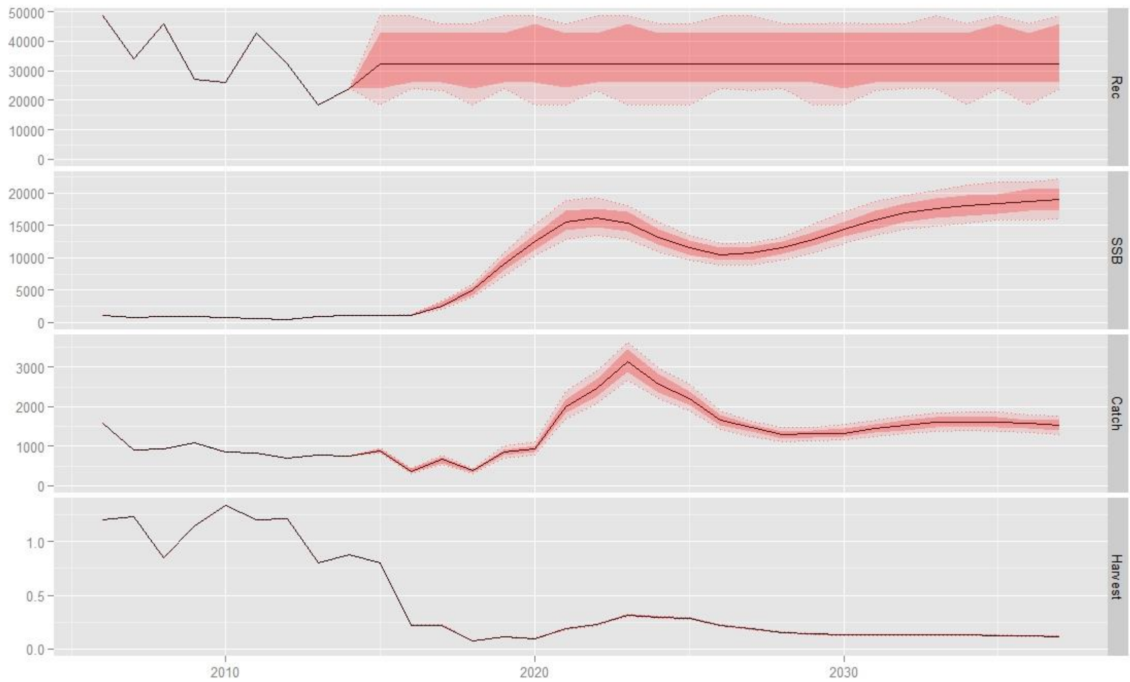


Figure 5.2.2.13.1. Hake in GSA 19. Management Strategy Evaluation.

5.2.3 STOCK ASSESSMENT OF RED MULLET IN GSA 17-18

Stock Identification

Red mullet (*Mullus barbatus*) is evenly distributed in the whole Adriatic and the isolation of the Adriatic population was assessed by molecular and Bayesian analysis (Maggio *et al.*, 2009). From this study was observed a limited gene flow ascribable to really low adult migration and a reduced passive drift of pelagic larvae from and to the Adriatic Sea. Garoia *et al.* (2004) developed a set of microsatellite marker, revealing a significant overall heterogeneity within the red mullet Adriatic stock: this result indicates that this species may constitute local subpopulations that remain partly isolated from each other. However, the fortuity of genetic differences among samples indicated that red mullet in the Adriatic likely belongs to a single population. Besides, no correlation between geographic distance and genetic differentiation has been detected. The observed genetic fragmentation could be explained by a passive dispersion of larvae due to marine currents, from random changes in allele frequencies or from fishing pressure. Although the red mullet is distributed in the entire Adriatic, the density of the population is not the same in space. For example, Arneri and Jukić (1986) found that the biomass index between Italian and Croatian waters is about 1:4.

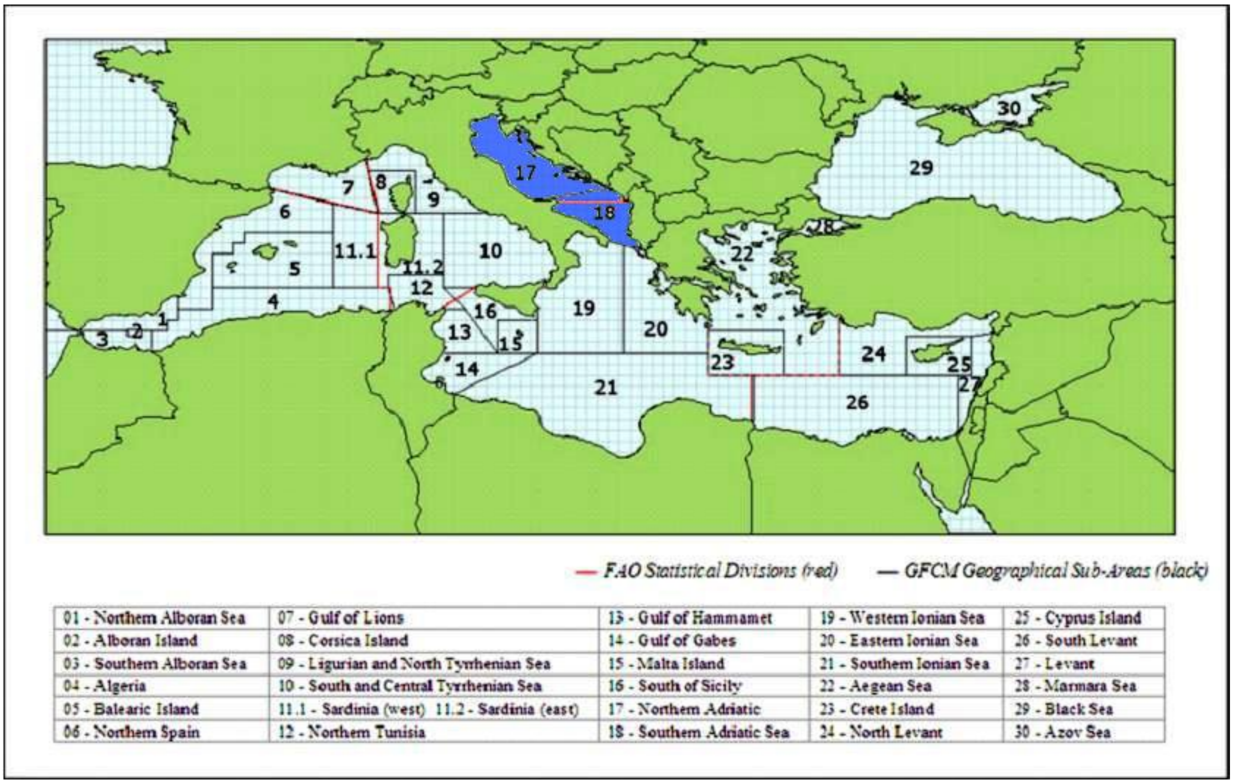


Figure 5.2.3.1.1. Geographical location of GSAs 17 and 18.

Growth

According to Jardas (1996), red mullet grow up to 30 cm, with females growing faster and bigger than males. In table 5.2.3.2.1. are showed the Von Bertalanffy growth function parameters available for this species.

Table 5.2.3.2.1. Red mullet in GSA 17 and 18. Von Bertalanffy growth function in the Adriatic Sea (the references of the table are from Vrgoc *et al.*, 2004).

Author	Sex	L_∞ (cm)	K (yr^{-1})	t_0 (yr)	Φ'
Scaccini (in Levi *et al.*, 1994)	M+F	27.49	0.5	-0.25	5.93
Jukić and Piccinetti, 1988	M+F	27.0	1.8		7.18
Marano, 1994; Ungaro *et al.*, 1994	M+F	19.70	0.360	-1.18	4.94
Vrgoč, 1995 ("Hvar")	M+F	27.75	0.274	-0.616	5.35
Marano, 1996; Marano *et al.*, 1998b, c	M	27	0.184	-1.92	4.90
	F	34.5	0.156	-1.53	5.22
	M+F	31.5	0.182	-1.45	5.19
	M+F (Bhatt)	26.3	0.45		5.74
Ardizzone, 1998	M+F	27.50	0.50		5.93
Marano, 1998b, c	M	22.5	0.24	-1.29	4.80
	F	26.2	0.23	-1.41	5.06
	M+F	22.5	0.38	-0.63	5.26
	M+F (Bhatt)	25.4	0.25		5.08
	M+F (Surf.)	23	0.52		5.62
Vrgoč, 2000	M+F	26.86	0.295		5.36
EC XIV/298/96-EN, Ionian and Southern Adriatic	M+F	21.72	0.31		4.99
EC XIV/298/96-EN, Adriatic Sea	M+F	27.5	0.50		5.94

Length frequency distributions from the Italian, Croatian, Slovenian, Albanian and Montenegro fleets as well as from survey data (MEDITS) were converted into catch at age according to slicing, using the growth parameters obtained independently for males and females decided during the STECF-EWG 14-19.

Table 5.2.3.2.2. Red mullet in GSA 17 and 18. Growth parameters and length-weight relationship for red mullet used in the assessment.

L_∞ = 30	K = 0.4	t_0 = - 0.3	a = 0.009	b = 3.076

Maturity

Red mullet reproduction occurs in late spring and summer. Individuals reach sexual maturity during the first year of life, at length between 10 and 14 cm (Županović, 1963; Haidar, 1970; Jukić and Piccinetti, 1981; Marano et al., 1998; Vrgoč, 2000; Carbonara et al., 2015). Females bigger in size may have a greater reproductive fitness, not only from a quantitative (fecundity) but also from a qualitative point of view (vitellogenin and eggs dimensions) (Carbonara et al., 2015).

Table 5.2.3.3.1. Red mullet in GSA 17 and 18. Maximum size, size at first maturity and size at recruitment.

Sex	Combined
Maximum size observed	28.5
Size at first maturity	11.7
Recruitment size to the fishery	6
Reproduction season	May to August
Recruitment season	Late summer-autumn

Natural mortality

A vector of natural mortality rate at age was estimated using the PRODBIOM spreadsheet (Abella et *al.*, 1997).

Table 5.2.3.4.1. Red mullet in GSA 17 and 18. Natural mortality vector for red mullet in GSA 17-18 estimated using PRODBIOM.

Natural mortality (M)				
PERIOD	0	1	2	3+
2008-2014	1.03	0.71	0.65	0.62

Fisheries

5.2.3.1.1 General description of the fisheries

In the Adriatic, red mullet is mainly fished by bottom trawl nets. Smaller quantities are also caught with trammel-nets and gill nets.

Fishing closure for Italian trawlers: 45 days in late summer have been enforced in 2011-2014 for the Italian fleet. Before 2011 the closure period was 30 days in summer.

The minimum legal landing size based on EC regulation 1967/2006 is 11 cm TL.

Along Croatian coast bottom trawl fisheries is mainly regulated by spatial and temporal fisheries regulation measures, and about 1/3 of territorial sea is closed for bottom trawl fisheries over whole year. Also bottom trawl fishery is closed half year in the majority of the inner sea. Minimum landing size for red mullet is the same like in the EC regulation.

Mannini and Massa (2000) analyzed trends of the red mullet landings in the Adriatic from 1972 to 1997. In that period, the landings showed an overall increase. This positive trend was constant in the Western Adriatic, while in the Eastern Adriatic landings decreased during the second half of the 1990s.

5.2.3.1.2 Management regulations applicable in 2015

Italy and Slovenia :

- In Italy and Slovenia the main rules in force are based on the applicable EU regulations (mainly EC regulation 1967/206):
- Minimum landing sizes: 11 cm TL for red mullet (valid also for Croatia).
- Cod-end mesh size of trawl nets: 40 mm (stretched, diamond meshes) till 30/05/2010. From 1/6/2010 the existing nets have been replaced with a cod end with 40 mm (stretched) square meshes or a cod-end with 50 mm (stretched) diamond meshes.
- Towed gears are not allowed within three nautical miles from the coast or at depths less than 50 m when this depth is reached at a distance less than 3 miles from the coast.
- Set net minimum mesh size: 16 mm stretched.
- Set net maximum length x vessel x day: 5,000 m

Croatia

Since the accession of Croatia to the EU the 1st if July 2013, the same regulations of Italy and Slovenia are implemented. Furthermore the following regulation for OTB are applied, especially in specific areas (Fig. 4):

1. Ordinance on Commercial Fishing at Sea (Official Journal no. 63/2010, 141/2010, 148/2010, 52/2011 and 144/2011) in parts which remain in force after the Croatian entry into the European Union:

- Article 3, paragraph 1 (minimum size of cod-end in the inner sea)
- Article 4 (spatial regulation considering the power of propelling engine)
- Article 5, paragraph 1 (permanent ban for certain zones)
- Article 6 and 7 (spatial-temporal ban to protect immature fish and other marine organisms)
- Article 8 and 9 – regulation in E zone

- Article 10 – regulation in F zone
- Article 11 – regulation in G zone
- Article 32 - ban on the issuance of new licences and entry of new types of fishing (fishing tools and equipment) to the valid licences.

2. Ordinance on fishing gear and equipment for commercial fishing in the sea (Official Journal, no. 148/2010, 25/2010) in parts which provide design and technical characteristics of the fishing gear and equipment, and the amount of gear that can be used in fishing (if it is not regulated by EC Regulations).
3. Ordinance on privileges for commercial fishing at the sea and the register of issued privileges (Official Journal no. 144/2010, 123/2011, 53/2012 and 98/2012.) which defines the conditions for transfer of rights from one valid licence to another valid licence and the terms of transfer of licences from one fishing vessel to another.
4. Ordinance on special habitats of fish and other marine organisms, and regulation of fishing in the Velebit Channel, Novigrad and Karin Sea, Prokljan Lake, Marina Bay and Neretva Channel (Official Journal, no. 148/2004, 152/2004, 55/2005, 96/2006, 123/2009 and 130/2009) which prohibits fishing by bottom trawling tools in specific habitats and in areas of the fishing sea with a special fishing regulation (Velebit Channel, Novigrad and Karin Sea, Prokljan Lake, Marina Bay and the Neretva Channel).

5.2.3.1.3 Landings

Official EU DCF landings data for red mullet in GSA 17 are available for the period 2002-2014 and from 2002 to 2014 in GSA 18.
In GSA 17 for 2004 are not reported data, for 2002 and 2003 data are available for Italy only and for 2005 available only for Slovenian.
For Croatia are reported data from 2013, from the accession to the EU.
Landings in GSA 18 are reported for all years.

Table 5.2.3.5.3.1. Red mullet in GSA 17 and 18. Annual landings (tons) from 2002 to 2014.

Year	Total landings	Area	Year	Total landings	Area
2002	2683.406	SA 17	2002	3203.810	SA 18
2003	2608.116	SA 17	2003	2061.756	SA 18
2005	4.360	SA 17	2004	2063.625	SA 18
2006	3102.502	SA 17	2005	1449.336	SA 18
2007	3304.881	SA 17	2006	1933.242	SA 18
2008	3160.312	SA 17	2007	1802.106	SA 18
2009	2436.081	SA 17	2008	960.818	SA 18
2010	1797.420	SA 17	2009	1031.290	SA 18
2011	1896.316	SA 17	2010	646.182	SA 18
2012	1527.885	SA 17	2011	531.745	SA 18
2013	3074.147	SA 17	2012	2096.281	SA 18
2014	3550.143	SA 17	2013	1249.809	SA 18
			2014	1272.209	SA 18

No landings of red mullet are reported from Montenegro or Albania in the Official EU DCF.

Table 5.2.3.5.3.2. Red mullet in GSA 17 and 18. Annual landings (tons) by fishery gear from 2002 to 2014.

Landings	Gear	Year	Area	Landings	Gear	Year	Area
208.560	GNS	2002	SA 17	1797.129	OTB	2010	SA 17
89.601	GNS	2002	SA 18	43.973	GNS	2010	SA 18
2474.846	OTB	2002	SA 17	1.430	GTR	2010	SA 18
3114.210	OTB	2002	SA 18	600.779	OTB	2010	SA 18
214.493	GNS	2003	SA 17	31.225	GNS	2011	SA 17
311.954	GNS	2003	SA 18	1824.652	OTB	2011	SA 17
2393.623	OTB	2003	SA 17	36.189	TBB	2011	SA 17
1749.802	OTB	2003	SA 18	37.119	GNS	2011	SA 18
82.496	GNS	2004	SA 18	0.398	GTR	2011	SA 18
1981.129	OTB	2004	SA 18	494.227	OTB	2011	SA 18
4.360	OTB	2005	SA 17	17.571	GNS	2012	SA 17
99.337	GNS	2005	SA 18	1467.157	OTB	2012	SA 17
1349.999	OTB	2005	SA 18	43.156	TBB	2012	SA 17
3102.502	OTB	2006	SA 17	7.118	GNS	2012	SA 18
123.499	GNS	2006	SA 18	0.553	GTR	2012	SA 18
6.270	GTR	2006	SA 18	2088.610	OTB	2012	SA 18
1803.474	OTB	2006	SA 18	10.456	GNS	2013	SA 17
3304.881	OTB	2007	SA 17	3032.739	OTB	2013	SA 17
119.771	GNS	2007	SA 18	30.953	TBB	2013	SA 17
2.739	GTR	2007	SA 18	47.026	GNS	2013	SA 18
1679.597	OTB	2007	SA 18	1202.783	OTB	2013	SA 18
3160.312	OTB	2008	SA 17	7.649	GNS	2014	SA 17
41.919	GNS	2008	SA 18	3478.883	OTB	2014	SA 17
4.704	GTR	2008	SA 18	63.583	TBB	2014	SA 17
914.195	OTB	2008	SA 18	4.532	GNS	2014	SA 18
2436.071	OTB	2009	SA 17	18.112	GTR	2014	SA 18
75.874	GNS	2009	SA 18	1249.565	OTB	2014	SA 18
0.814	GTR	2009	SA 18				
954.602	OTB	2009	SA 18				

About the landings size-structure, for Italy in GSA 17 length frequency data are available from 2006 instead for Slovenia are not reported lfd data; in GSA 18 lfd starts from 2004, but data are available from this year only for OTB.

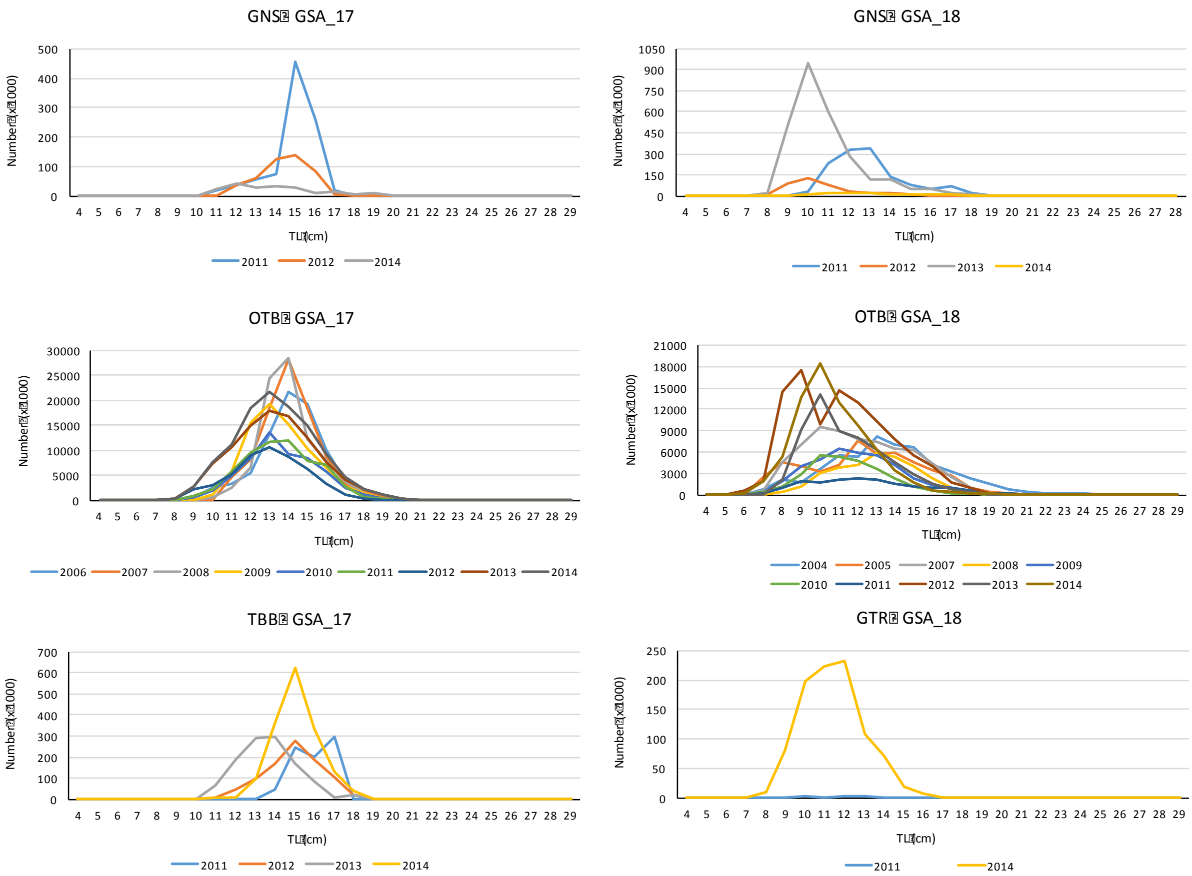


Figure 5.2.3.5.3.1. Red mullet in GSA 17 and 18. Landings length frequency distribution for red mullet in GSA 17 and GSA 18 by gear.

In the following tables, landings age-structure for red mullet in GSA 17 and GSA 18 by gear.

Table 5.2.3.5.3.3. Red mullet in GSA 17 and 18. Landings age-structure for GNS in GSA 17.

GNS_17	2011	2012	2013
0	24.236	9.997	30.969
1+	889.406	444.242	171.399

Table 5.2.3.5.3.4. Red mullet in GSA 17 and 18. Landings age-structure for TBB in GSA 17.

TBB_17	2011	2012	2013	2014
0	0	13.797	97.393	9.729
1+	793.177	894.383	1032.185	1593.261

Table 5.2.3.5.3.5. Red mullet in GSA 17 and 18. Landings age-structure for OTB in GSA 17.

OTB_17	2006	2007	2008	2009	2010	2011	2012	2013	2014
0	7126.91	6049.27	4039.05	9362.35	8844.33	10194.55	12453.83	23493.84	24896.73
1	73088.89	84304.77	82496.95	67068.72	46606.62	48992.08	37715.80	71493.82	85228.89
2	2130.56	2649.01	1737.30	1855.44	1480.38	769.61	486.11	3604.19	3772.95
3+	2.07	43.54	0.27	0.52	13.76	0.88	16.75	61.48	52.47

Table 5.2.3.5.3.6. Red mullet in GSA 17 and 18. Landings age-structure for GTR in GSA 17.

GTR_18	2011	2014
0	3.878	548.541
1+	10.375	403.904

Table 5.2.3.5.3.7. Red mullet in GSA 17 and 18. Landings age-structure for GNS in GSA 17.

GNS_18	2011	2012	2013	2014
0	322.917	312.414	2120.62	34.04
1	951.344	93.112	608.595	99.153
2+	26.567	4.085	19.504	5.118

Table 5.2.3.5.3.8. Red mullet in GSA 17 and 18. Landings age-structure for OTB in GSA 17.

OTB_18	2004	2005	2007	2008	2009	2010	2011	2012	2013	2014
0	14556.54	19857.55	32162.51	9191.11	18867.28	16170.07	7356.79	61305.75	35696.20	54284.22
1	33788.92	28483.21	33606.73	22120.63	19203.59	12000.03	8635.47	40232.70	22825.08	20540.94
2	4932.22	1645.91	1333.72	398.03	955.27	260.29	1113.38	1419.14	691.74	497.98
3+	597.17	0.67	50.66	29.82	21.18	25.12	25.54	10.71	9.08	19.35

5.2.3.1.4 Discards

Discards data were reported to STECF EWG 15-16 through the DCF.
Data are available from 2005, only for Slovenia; for Italy in GSA 17 data start from 2010, while in GSA 18 from 2009; for Croatia from 2013.

Table 5.2.3.5.4.1. Red mullet in GSA 17 and 18. Annual discards (tons) from 2005 to 2014.

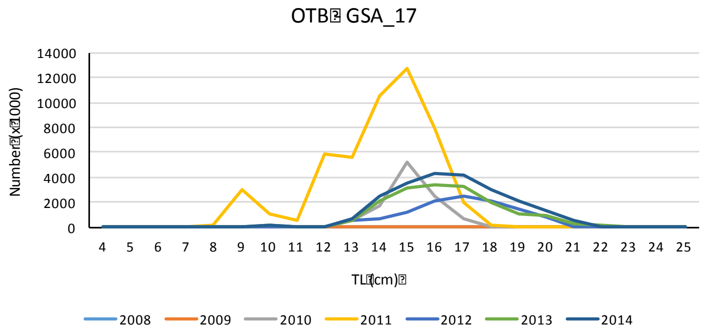
Total discards	**Year**	**Area**	**Total discards**	**Year**	**Area**
0.133	2005	SA 17	14.734	2009	SA 18
0.037	2006	SA 17	35.007	2010	SA 18
0.255	2007	SA 17	19.302	2011	SA 18
0.040	2008	SA 17	434.053	2012	SA 18
0.056	2009	SA 17	19.436	2013	SA 18
183.015	2010	SA 17	119.616	2014	SA 18
803.564	2011	SA 17			
324.664	2012	SA 17			
453.522	2013	SA 17			
1001.686	2014	SA 17			

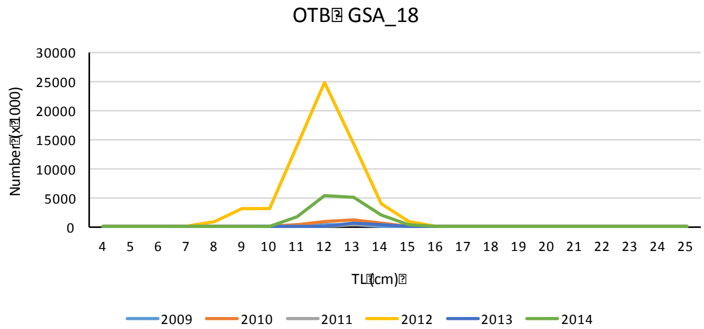
Table 5.2.3.5.4.2. Red mullet in GSA 17 and 18. Annual discards (tons) by fishery gear from 2005 to 2014.

Discards	**Gear**	**Year**	**Area**	**Discards**	**Gear**	**Year**	**Area**
0.133	OTB	2005	SA 17	14.734	OTB	2009	SA 18
0.037	OTB	2006	SA 17	35.007	OTB	2010	SA 18
0.255	OTB	2007	SA 17	5.380	GNS	2011	SA 18
0.040	OTB	2008	SA 17	13.922	OTB	2011	SA 18
0.056	OTB	2009	SA 17	434.053	OTB	2012	SA 18

183.015	OTB	2010	SA 17	1.385	GNS	2013	SA 18
803.564	OTB	2011	SA 17	18.051	OTB	2013	SA 18
324.664	OTB	2012	SA 17	119.616	OTB	2014	SA 18
453.522	OTB	2013	SA 17				
1001.686	OTB	2014	SA 17				

Regarding discards size-structure, length frequency distribution data start from 2008 in GSA 17, whereas from 2009 in GSA 18.





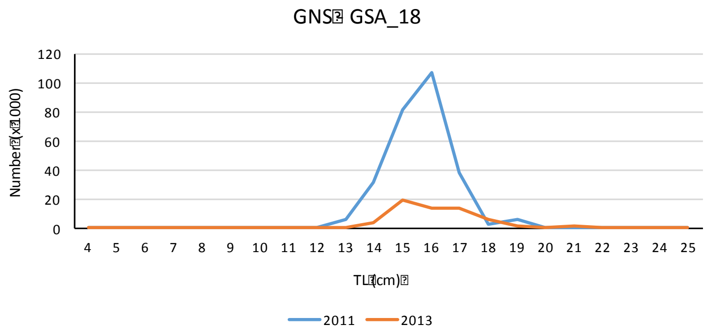


Figure 5.2.3.5.4.1. Red mullet in GSA 17 and 18. Discards length frequency distribution for red mullet in GSA 17 and GSA 18 by gear.

In the following tables, discards age-structure for red mullet in GSA 17 and GSA 18 by gear.

Table 5.2.3.5.4.3. Red mullet in GSA 17 and 18. Discards age-structure for OTB in GSA 17.

OTB_17	2008	2009	2010	2011	2012	2013	2014
0	0.001	0.001	11.235	5745.184	16.982	244.838	241.968
1	0.429	1.291	10842.4	43833.48	7464.79	12749.19	15503.12
2+	0.429	0.413	0	287.104	4284.723	4340.458	7002.841

Table 5.2.3.5.4.4. Red mullet in GSA 17 and 18. Discards age-structure for GNS in GSA 18.

GNS_18	2011	2013
0	0	0
1	264.649	49.328
2+	9.307	9.188

Table 5.2.3.5.4.5. Red mullet in GSA 17 and 18. Discards age-structure for OTB in GSA 18.

OTB_18	2009	2010	2011	2012	2013	2014
0	535.505	1034.37	92.427	25234.22	227.916	2796.875
1+	1200.713	3100.978	1138.378	40045.994	1601.852	12136.83

5.2.3.1.5 Fishing effort

In Croatia and Slovenia, red mullet is exploited by OTB, for this reason, here are reported only the total annual nominal effort and GT*days at sea (Tab 5.2.3.5.5.1 and 5.2.3.5.5.2 respectively). Instead for Italy, where red mullet is caught by different fisheries, were reported both the annual per gear and the total annual nominal effort and GT*days at sea (Tab 5.2.3.5.5.3 and 5.2.3.5.5.4, respectively).

Table 5.2.3.5.5.1. Red mullet in GSA 17 and 18. Annual nominal effort and GT*days at sea for Croatian fleet.

Country	**Year**	**Kw*days**	**GT*days at sea**
HRV	2012	15985566.18	3482697.83
HRV	2013	23186903.52	4946529.22
HRV	2014	23372460.93	4955926.82

Table 5.2.3.5.5.2. Red mullet in GSA 17 and 18. Annual nominal effort and GT*days at sea for Slovenian fleet.

Country	**Year**	**Kw*days**	**GT*days at sea**
SVN	2005	112663.45	9155.06
SVN	2006	143525.6	12290.86
SVN	2007	183977.9	17413.43
SVN	2008	198180.52	18858.18
SVN	2009	200880.44	18191.47
SVN	2010	207861.86	18235.28
SVN	2011	188620.91	17781.59
SVN	2012	153645.5	15063.24
SVN	2013	113693.6	11960.07
SVN	2014	99847.2	9372.11

Table 5.2.3.5.5.3. Red mullet in GSA 17 and 18. Annual per gear nominal effort and GT*days at sea for Italian fleet.

Country	**Year**	**Gear**	**Kw*days**	**GT*days at sea**	**Country**	**Year**	**Gear**	**Kw*days**	**GT*days at sea**
ITA	2004	GNS	5933656	313229	ITA	2010	GNS	3966780	247279
ITA	2004	GTR	2223885	161295	ITA	2010	GTR	885271	79765
ITA	2004	OTB	42275313	7835736	ITA	2010	OTB	29950838	5905490
ITA	2004	TBB	4232537	1003129	ITA	2010	TBB	3817491	921158
ITA	2005	GNS	7016405	357318	ITA	2011	GNS	5094267	281318
ITA	2005	GTR	1790725	149970	ITA	2011	GTR	777735	79593
ITA	2005	OTB	37644492	7519968	ITA	2011	OTB	27901536	5382854

ITA	2005	TBB	3812915	785589	ITA	2011	TBB	2584717	665155
ITA	2006	GNS	6101313	333456	ITA	2012	GNS	5709787	297775
ITA	2006	GTR	1225882	111072	ITA	2012	GTR	777735	79593
ITA	2006	OTB	34641421	6741848	ITA	2012	OTB	23842721	4799392
ITA	2006	TBB	4946237	1052912	ITA	2012	TBB	3254187	772706
ITA	2007	GNS	3819332	227006	ITA	2013	GNS	3752111	246659
ITA	2007	GTR	1787867	146961	ITA	2013	GTR	60158	8196
ITA	2007	OTB	32249251	6351016	ITA	2013	OTB	23125950	4640270
ITA	2007	TBB	5231834	1096364	ITA	2013	TBB	2769675	657556
ITA	2008	GNS	3346053	186560	ITA	2014	GNS	4072122	255055
ITA	2008	GTR	1021626	83968	ITA	2014	GTR	427424	51077
ITA	2008	OTB	31502213	6121887	ITA	2014	OTB	22171347	4299825
ITA	2008	TBB	4136346	843741	ITA	2014	TBB	3729815	892595
ITA	2009	GNS	4485963	253065					
ITA	2009	GTR	837252	80946					
ITA	2009	OTB	32768358	6217030					
ITA	2009	TBB	4386154	1045203					

Table 5.2.3.5.5.4. Red mullet in GSA 17 and 18. Annual nominal effort and GT*days at sea for Italian fleet.

Country	Year	Kw*days	GT*days at sea
ITA	2004	54665391	9313389
ITA	2005	50264537	8812845
ITA	2006	46914853	8239288
ITA	2007	43088284	7821347
ITA	2008	40006238	7236156
ITA	2009	42477727	7596244
ITA	2010	38620380	7153692
ITA	2011	36358255	6408920
ITA	2012	33347751	5930415
ITA	2013	29707894	5552681
ITA	2014	30400708	5498552

Scientific surveys

5.2.3.1.6 Survey #1 (MEDITS)

5.2.3.1.6.1 Methods

The MEDITS (MEDiterranean International Trawl Survey) survey is a trawls survey occurring in all European countries and included in the Data Collection Framework. According to the MEDITS protocol (Bertrand et al., 2002), it occurs every year during springtime carring out a random stratified sampling by depth (5 strata: 10-50 m, 50-100 m, 100-200 m, 200-500m and over 500 m). Hauls numbers for each stratum is proportional to the surface of the stratum and their positions were randomly selected and maintain fixed. The same gear (GOC 73, by P.Y. Dremière, IFREMER-Sète), with a 20 mm stretched mesh size in the cod-end, was employed throughout the GSAs. Details on its characteristics and performance are reported in Dremière and Fiorentini (1996). All the abundance data (number of fish per surface unit) were standardized to square kilometer, using the swept area method.

5.2.3.1.6.2 Geographical distribution

Red mullet (*Mullus barbatus*) is consistently distributed in the whole Adriatic and the isolation of the Adriatic population was assessed by molecular and Bayesian analysis (Maggio *et al.*, 2009).
In the following maps it is possible to observe the distribution of recruits along the western coast, and of spawners on the eastern side.

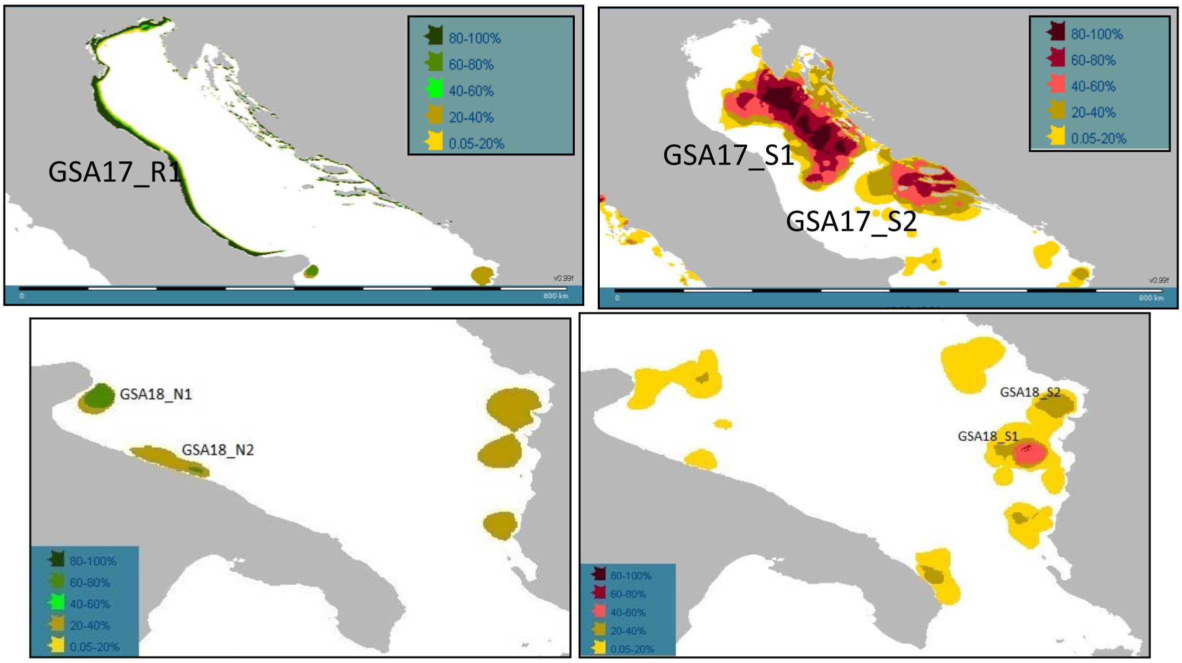
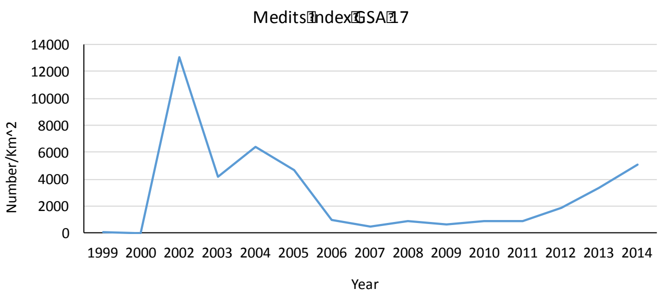


Figure 5.2.3.6.1.2.1. Red mullet in GSA 17 and 18. Distribution of red mullet recruits (left graphs) and spawners (right graphs) in the spring/summer period (MEDITS SURVEY, from MEDISEH MAREA project) in GSA 17 and 18.

5.2.3.1.6.3 Trends in abundance and biomass

Abundance and biomass indices were calculated by GSAs using the script prepared during the STECF EWG 15-06, on the base of DCF data call. Figure 5.2.3.6.1.3.1. shows the trend of abundance of red mullet in GSA 17 and 18 respectively.



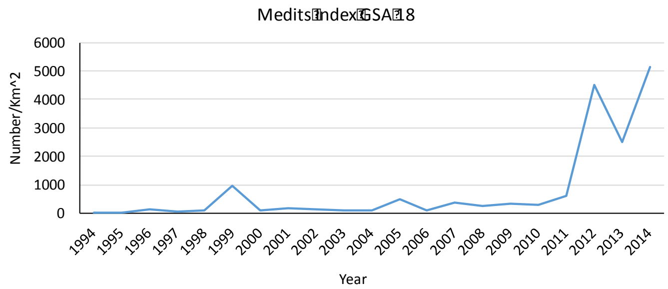
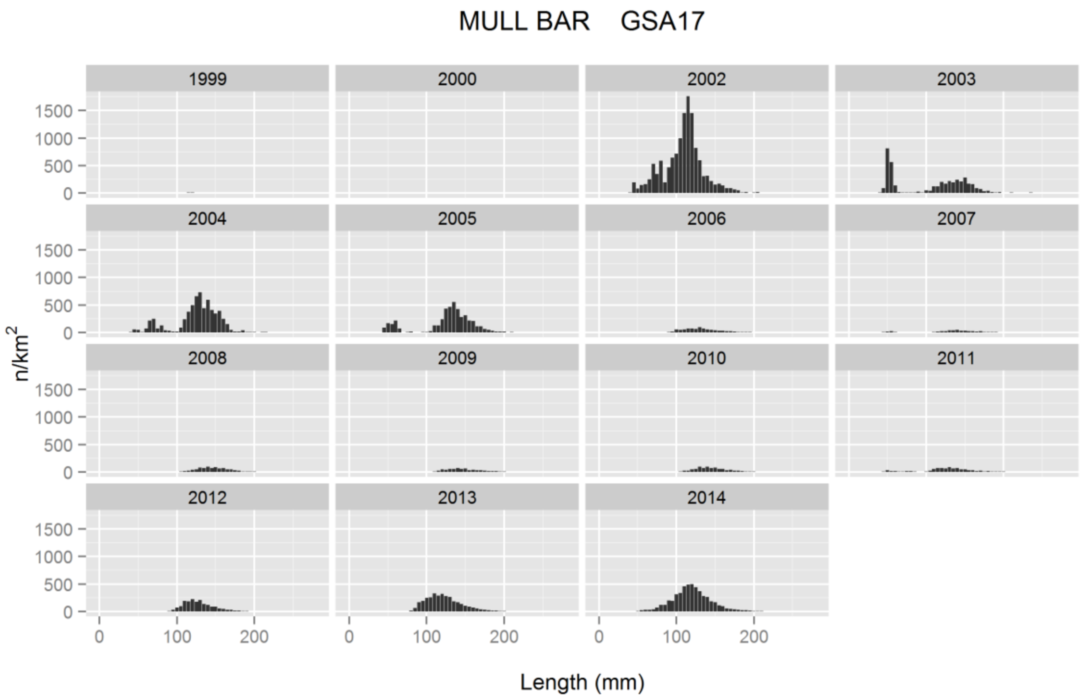


Figure 5.2.3.6.1.3.1. Red mullet in GSA 17 and 18. Abundance indeces from MEDITS survey in GSA 17 (above) and GSA 18 (below).

5.2.3.1.6.4 Trends in abundance by length or age

Following figures represent trends of red mullet by length and year for GSA 17 and GSA 18 (Fig. 5.2.3.6.1.4.1.). Values were extracted from MEDITS survey utilizing the script developed within STECF EWG 15-06. An exceptional recruitment was observed in 2012-2014 in GSA 18 in the MEDITS survey. This is also evident in the commercial data (Table 5.2.3.7.2.1.) in the same GSA. A similar pattern was not observed in GSA 17.



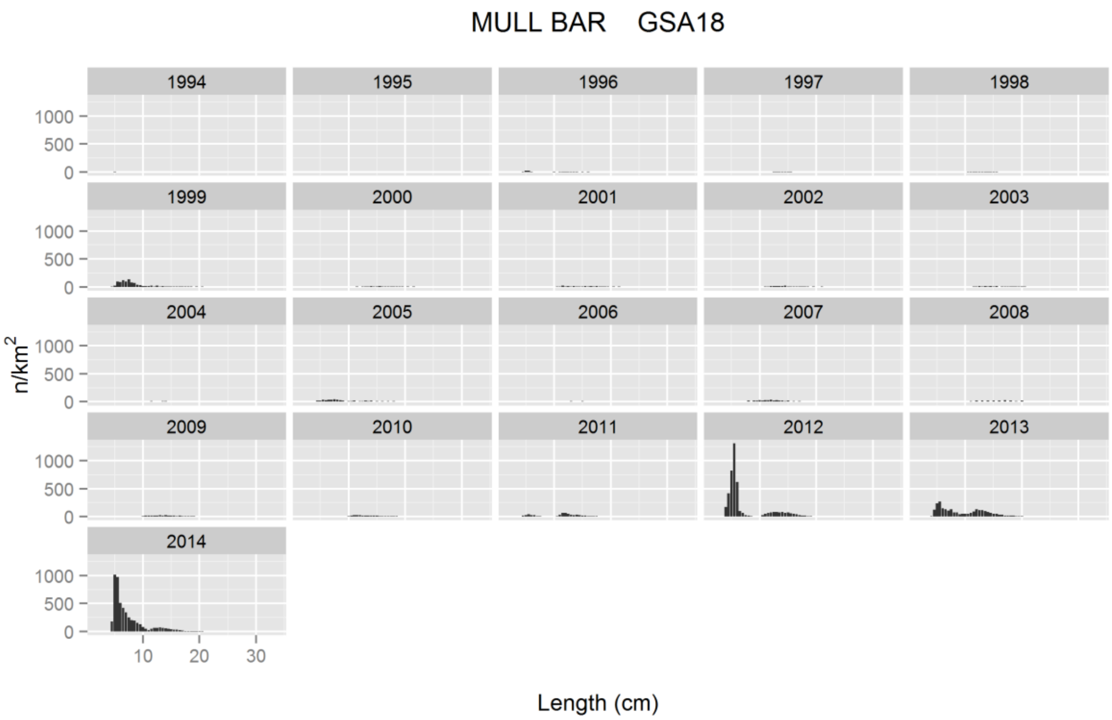


Figure 5.2.3.6.1.4.1. Red mullet in GSA 17 and 18. Density indices (N/Km^2) per length class in GSA 17 (above) and GSA 18 (below).

Stock Assessment

Stock assessment has been conducted using XSA method.

5.2.3.1.7 Methods

XSA *(Extended Survival Analysis)*

FLR libraries were employed in order to carry out an XSA assessment.

5.2.3.1.8 Input data

The red mullet stock in GSA 17 and GSA 18 was assessed separately so far; during the STECF EWG 15-06 was carried out an assessment combining the two ones. XSA was carried out utilizing data presented during the last GFCM WGSAD of November 2015. The time series starts from 2008-2014 both for catches data and for tuning file, because Croatian data before 2008 are not very reliable. As Slovenian lfd are not available in DCF data, it was assumed that are the same of Croatia; moreover considering the small amounts of Slovenian catches, it was decided to consider them together with Croatian ones.

Table 5.2.3.7.2.1. Red mullet in GSA 17 and 18. Catch numbers-at-age matrix (thousands).

Age/Year	2008	2009	2010	2011	2012	2013	2014
0	52381.28	63453.24	47683.96	91890.24	150398.39	86565.46	130381.8
1	137938.63	140469.69	121015.77	128430.43	167811.25	164933.21	194846.9
2	12460.92	10434.44	9485.82	10468.43	19255.95	11726.03	10402.54
3+	844.61	1215.39	623.45	1823.98	1691.38	824.29	651.18

Table 5.2.3.7.2.2. Red mullet in GSA 17 and 18. Catches (landings+discard) in tonnes.

Year	2008	2009	2010	2011	2012	2013	2014
Tonnes	6708	5693	3766	4825	6827	5612	6603

Table 5.2.3.7.2.3. Red mullet in GSA 17 and 18. Weights-at-ag in the stock and in the catches (kg).

Age/Year	2008	2009	2010	2011	2012	2013	2014
0	0.019	0.018	0.014	0.015	0.010	0.014	0.014
1	0.034	0.026	0.021	0.020	0.023	0.021	0.021
2	0.068	0.064	0.055	0.059	0.066	0.064	0.057
3+	0.153	0.130	0.120	0.124	0.137	0.143	0.135

Table 5.2.3.7.2.4. Red mullet in GSA 17 and 18. Maturity and natural mortality by age.

Age	0	1	2	3+
Mat	0.16	0.92	1.00	1.00
M	1.03	0.71	0.65	0.62

Table 5.2.3.7.2.5. Red mullet in GSA 17 and 18. MEDITS index by age for GSA 17.

Age/Year	2008	2009	2010	2011	2012	2013	2014
0	70.052	56.178	79.986	308.812	668.767	1677.434	2596.396
1	760.064	552.571	714.692	550.662	1153.972	1642.788	2396.084
2	69.721	76.151	75.498	47.371	39.963	77.302	111.211
3+	2.553	1.65	2.549	1.68	2.295	1.571	3.731

Table 5.2.3.7.2.6. Red mullet in GSA 17 and 18. MEDITS index by age for GSA 18.

Age/Year	2008	2009	2010	2011	2012	2013	2014
0	38.74	97.6494	135.9146	422.2744	5562.9404	2474.2428	6827.4616
1	198.6775	277.5004	239.904	429.9147	1034.5157	1153.3057	734.746
2	71.4376	43.6564	32.3496	31.3921	60.236	75.942	54.1543
3+	7.6325	8.581	5.6757	3.4386	3.8759	5.4193	1.5952

5.2.3.1.9 Results

Sensitivity analysis was carried out to assess the effect of the main settings of the XSA.
Four runs were compared considering the following parameters: 0 for rage, 2 for qage, 4 for shk.yrs, 2 for shk.ages and values from 0.5 to 2 for fse. Results showed that the best fitting was observed using fse=2 (corresponding to Run 4), and it was chosen on the base of the best results taking account of residuals analysis and XSA diagnostics.
Comparison among runs is showed in figure 5.2.3.7.3.1., whereas figure 5.2.3.7.3.2. shows the residuals using fse=2.
The stability of the model was evaluated by the retrospective analysis, represented for fse=2 in figure 5.2.3.7.3.3. Moreover internal consistency of catches and survey indices for the best model are shown (figs. 5.2.3.7.3.4, 5.2.3.7.3.5, 5.2.3.7.3.6).

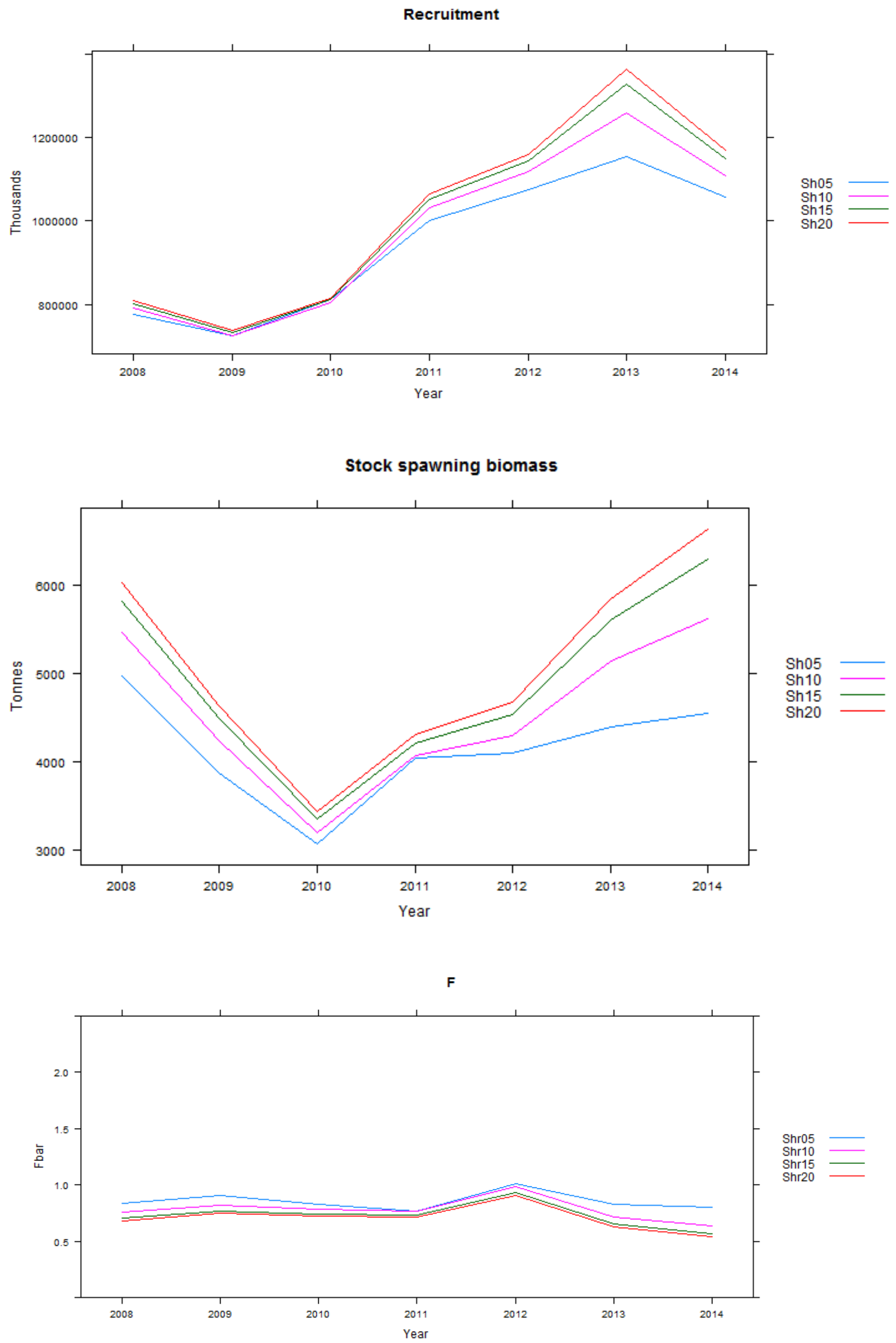


Figure 5.2.3.7.3.1. Red mullet in GSA 17 and 18. Sensitivity analysis using different fse.

Table 5.2.3.7.3.1. Red mullet in GSA 17 and 18. XSA run comparison: minimum, maximum and average residuals expressed as absolute value.

				MEDITS GSA 17			MEDITS GSA 18		
	fse	rage	qage	Min Residual	Max Residual	Average (abs value)	Min Residual	Max Residual	Average (abs value)
Run 1	0.5	0	2	-0.71	0.60	0.21	-0.73	0.87	0.22
Run 2	1	0	2	-0.59	0.45	0.16	-0.73	0.80	0.21
Run 3	1.5	0	2	-0.54	0.43	0.15	-0.72	0.79	0.21
Run 4	2	0	2	-0.52	0.42	0.15	-0.72	0.78	0.21

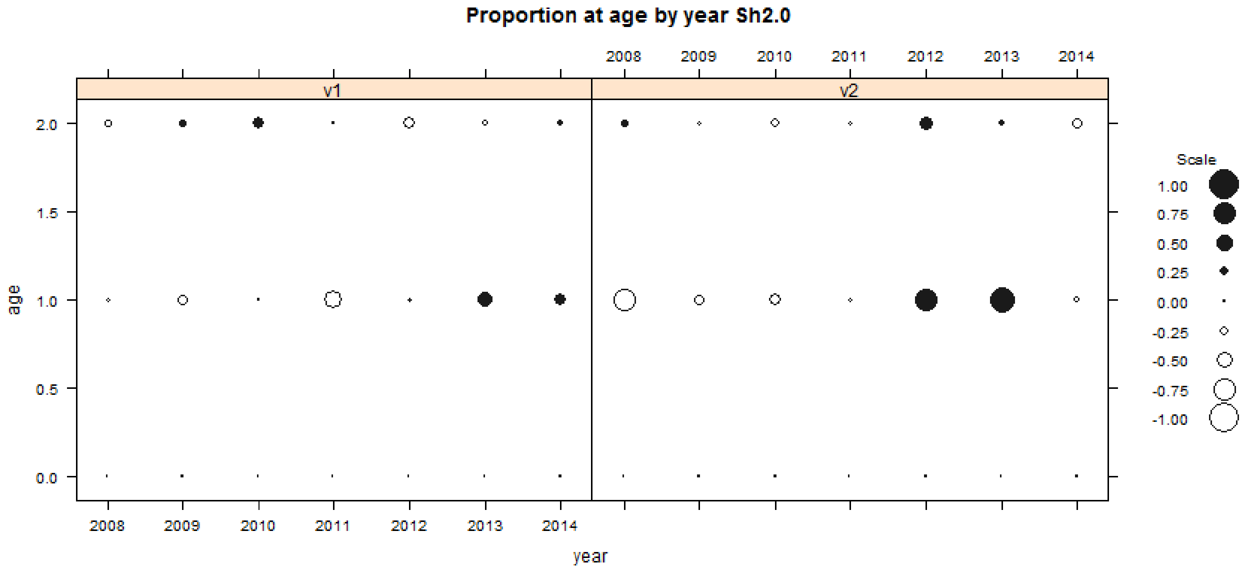


Figure 5.2.3.7.3.2. Red mullet in GSA 17 and 18. XSA residual analysis for MEDITS survey in GSA 17 (left) and for MEDITS in GSA 18 (right).

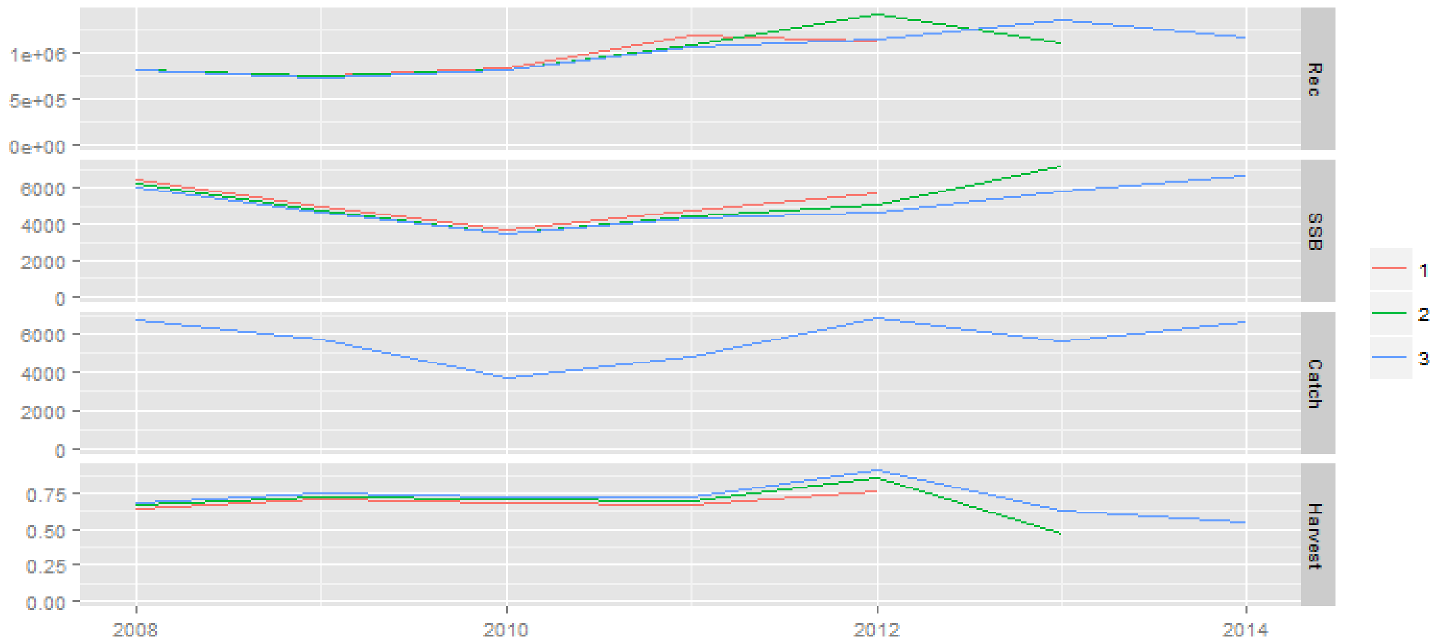


Figure 5.2.3.7.3.3. Red mullet in GSA 17 and 18. XSA retrospective analysis.

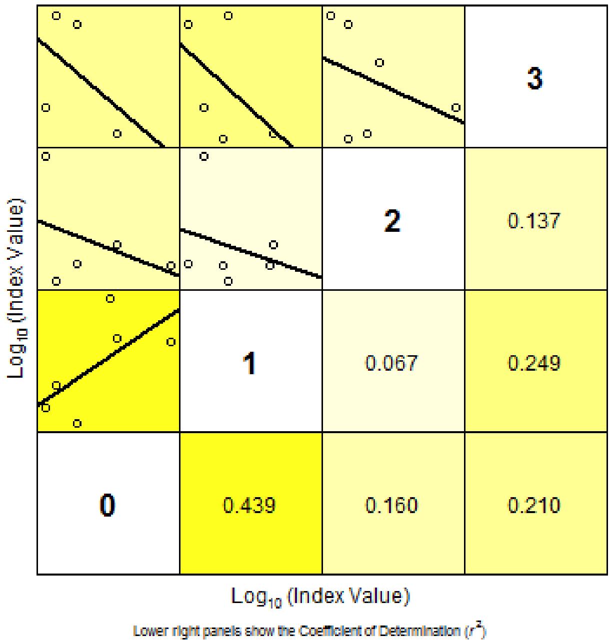


Figure 5.2.3.7.3.4. Red mullet in GSA 17 and 18. Internal consistency of the catches.

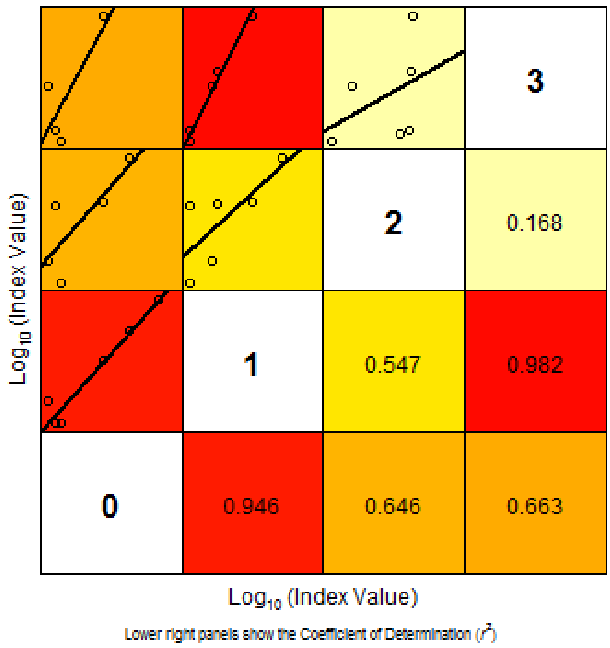


Figure 5.2.3.7.3.5. Red mullet in GSA 17 and 18. Internal consistency of MEDITS survey in GSA 17.

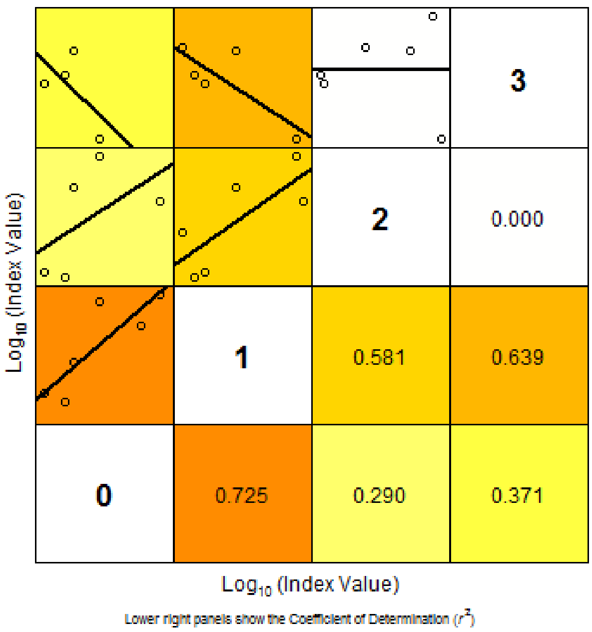


Figure 5.2.3.7.3.6. Red mullet in GSA 17 and 18. Internal consistency of MEDITS survey in GSA 18.

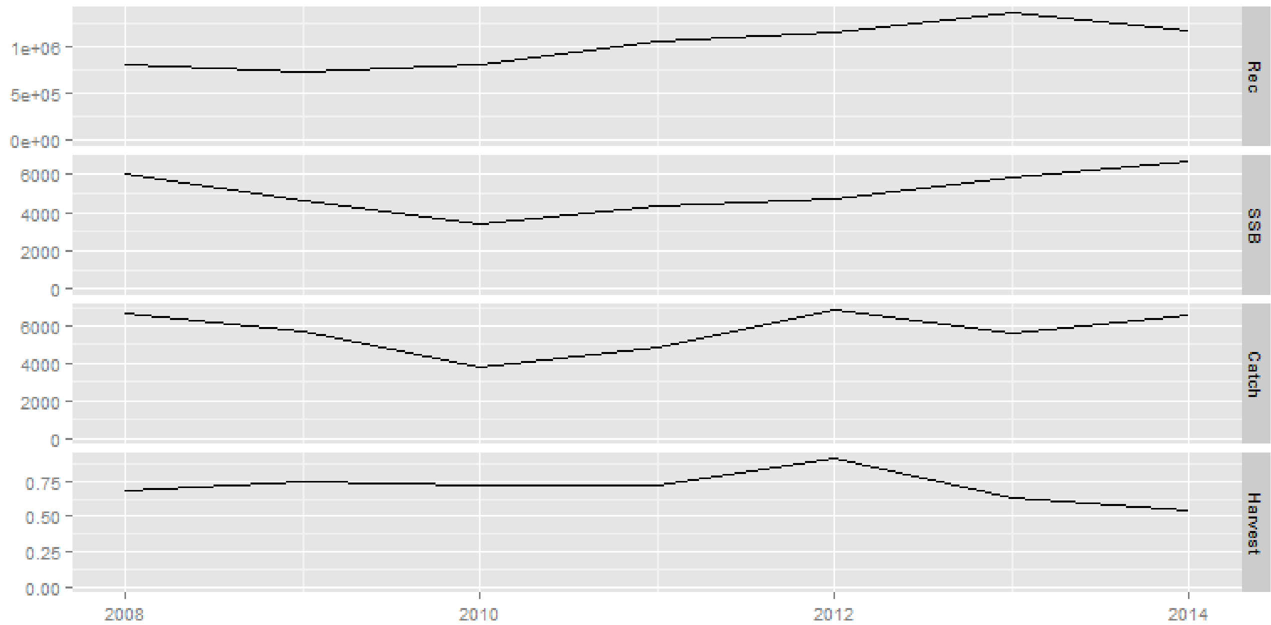


Figure 5.2.3.7.3.7. Red mullet in GSA 17 and 18. Final results.

Table 5.2.3.7.3.2. Red mullet in GSA 17 and 18. XSA summary results.

Year	Fbar(0-2)	SSB (t)	TB (t)	Recruitment (thousands)
2008	0.68	6030.3	13616.2	809474
2009	0.75	4642.2	11078.9	738865
2010	0.72	3438.7	9093.6	815927
2011	0.72	4305.6	11799.5	1065340
2012	0.90	4673.5	10086.5	1159098

2013	0.63	5852	15203.5	1363269
2014	0.54	6634.9	14348.6	1170654

Table 5.2.3.7.3.3. Red mullet in GSA 17 and 18. Stock number at age in thousands estimated by XSA from 2008 to 2014.

Age/Year	2008	2009	2010	2011	2012	2013	2014
0	809474	738865	815927	1065340	1159098	1363269	1170654
1	262843	257690	225867	262800	325429	323943	434974
2	40304	32506	28198	26193	39152	42331	43618
3+	2606	3606	1762	4299	3185	2850	2626

Table 5.2.3.7.3.4. Red mullet in GSA 17 and 18. Harvest at age estimated by XSA from 2008 to 2014.

Age/Year	2008	2009	2010	2011	2012	2013	2014
0	0.11	0.16	0.10	0.16	0.24	0.11	0.21
1	1.38	1.50	1.44	1.19	1.33	1.30	1.02
2	0.56	0.59	0.63	0.81	1.14	0.48	0.40
3+	0.56	0.59	0.63	0.81	1.14	0.48	0.40

The assessment conducted during the last GFCM, carried out only for GSA 18 using the same data and methodological approach as in the present assessment, resulted in a current level of fishing mortality equal to 0.48, which is only slightly lower compared the level estimated for the 2 GSAs combined (F=0.54).

Reference points

5.2.3.1.10 Methods

The yield per recruit analysis (YpR) was performed using the FLBRP routine. Thus it was possible to estimate some F-based Reference Points and $F_{0.1}$ was considered as proxy of FMSY.

5.2.3.1.11 Input data

The data were the same used for the XSA.

5.2.3.1.12 Results

Through FLBPR package were estimated the reference points, reported in table 5.2.3.8.3.1.

Table 5.2.3.8.3.1. Red mullet in GSA 17 and 18. Reference points estimated by the Yield per Recruit analysis.

Refpt	Harvest	Yield	Rec	SSB	Biomass
Vrgin	0.00	0.000	1	0.034	0.041
Msy	3.18E+120	0.013	1	0.000	0.000
Crash	41.66	0.012	1	0.000	0.000
F0.1	0.41	0.006	1	0.011	0.017
Fmax	9.91E+15	0.013	1	0.000	0.000
Spr.30	0.42	0.006	1	0.010	0.017

Data quality

The assessement of *Mullus barbatus* in GSA 17 and 18 was performed using all the data available. Specifically, both for GSA 17 and GSA 18 data from the last GFCM stock assessment were used. Data from Albania e Montenegro were provided by AdriaMed, as well as, Croatian data before the accession to the EU (years from 2008 to 2012). Some data needed to be reconstructed. In particular, for those years where discard and the respective length composition or only the length composition were not reported, these were reconstructed using the proportion and the size compositions estimated in the previous or in the following years.

Short term predictions 2015-2017

5.2.3.1.13 Method

A deterministic short term prediction for the period 2015 to 2017 was performed using the FLR routines provided by JRC, based on XSA results. This routine performs short terms for the whole fleet.

5.2.3.1.14 Input parameters

Input parameters were the same used in the XSA analysis and showed previously.

5.2.3.1.15 Results

Table 5.2.3.10.3.1. Red mullet in GSA 17 and 18. Short term forecast in different F scenarios.

Rationale	Ffactor	Fbar	Catch 2015	Catch 2016	Catch 2017	SSB 2016	SSB 2017	Change SSB 2016-2017(%)	Change Catch 2014-2016(%)
Zero catch	0	0.00	7587	0	0	9103	14153	55.5	-100.0
High long term yield (F0.1)	0.61	0.41	7587	4280	4558	7177	7665	6.8	-35.2
Status quo	0.1	0.07	7587	840	1145	8748	12739	45.6	-87.3
Different Scenarios	0.2	0.14	7587	1620	2097	8409	11484	36.6	-75.5
	0.3	0.20	7587	2346	2887	8085	10371	28.3	-64.5
	0.4	0.27	7587	3021	3541	7776	9382	20.7	-54.3

	0.5	0.34	7587	3650	4082	7480	8503	13.7	-44.7
	0.6	0.41	7587	4238	4528	7198	7719	7.2	-35.8
	0.7	0.47	7587	4787	4895	6928	7021	1.3	-27.5
	0.8	0.54	7587	5302	5195	6670	6398	-4.1	-19.7
	0.9	0.61	7587	5784	5441	6423	5841	-9.1	-12.4
	1	0.68	7587	6237	5641	6187	5343	-13.6	-5.5
	1.1	0.74	7587	6664	5803	5961	4896	-17.9	0.9
	1.2	0.81	7587	7065	5933	5745	4496	-21.7	7.0
	1.3	0.88	7587	7443	6037	5538	4137	-25.3	12.7
	1.4	0.95	7587	7801	6120	5341	3814	-28.6	18.1
	1.5	1.01	7587	8139	6185	5151	3524	-31.6	23.3
	1.6	1.08	7587	8459	6235	4970	3262	-34.4	28.1
	1.7	1.15	7587	8762	6274	4796	3026	-36.9	32.7
	1.8	1.22	7587	9050	6303	4629	2813	-39.2	37.1
	1.9	1.29	7587	9324	6324	4470	2621	-41.4	41.2
	2	1.35	7587	9585	6339	4317	2447	-43.3	45.2

Short term predictions 2015-2017 by fleet

5.2.3.1.16 Method

A deterministic short term prediction for the period 2015 to 2017 was performed using the FLR routines provided by JRC, based on XSA results.
Given that red mullet is exploited mainly by OTB, whereas other fisheries represent around the 5% of the cacthes, it was decided to carry out short term by fleet considering all the fisheries per Country, together as OTB.

5.2.3.1.17 Input parameters

Parameters are the same used in the short term by single fleet.

5.2.3.1.18 Results

Table 5.2.3.11.3.1. Red mullet in GSA 17 and 18. Short term forecast by fleet.

Fleet	Year	Catches	name	Partial_F
CRO	2015	2259.166996	fsq*1	0.188947171
CRO	2015	2259.166996	f0.1	0.188947171
ITA	2015	5137.117034	fsq*1	0.443379497
ITA	2015	5137.117034	f0.1	0.443379497
ALB	2015	525.6788918	fsq*1	0.037995085
ALB	2015	525.6788918	f0.1	0.037995085
MNT	2015	93.38576986	fsq*1	0.005874114
MNT	2015	93.38576986	f0.1	0.005874114
CRO	2016	2344.396527	fsq*1	0.188947171
CRO	2016	1603.6451	f0.1	0.113354019
ITA	2016	5298.414208	fsq*1	0.443379497
ITA	2016	3648.96759	f0.1	0.265994182

ALB	2016	572.3280636	fsq*1	0.037995085
ALB	2016	386.8533379	f0.1	0.022794179
MNT	2016	107.5640333	fsq*1	0.005874114
MNT	2016	72.66640479	f0.1	0.003524024
CRO	2017	2230.494045	fsq*1	0.188947171
CRO	2017	1949.564154	f0.1	0.113354019
ITA	2017	5310.53496	fsq*1	0.443379497
ITA	2017	4022.83043	f0.1	0.265994182
ALB	2017	525.769682	fsq*1	0.037995085
ALB	2017	469.3795084	f0.1	0.022794179
MNT	2017	96.8793128	fsq*1	0.005874114
MNT	2017	85.5993025	f0.1	0.003524024

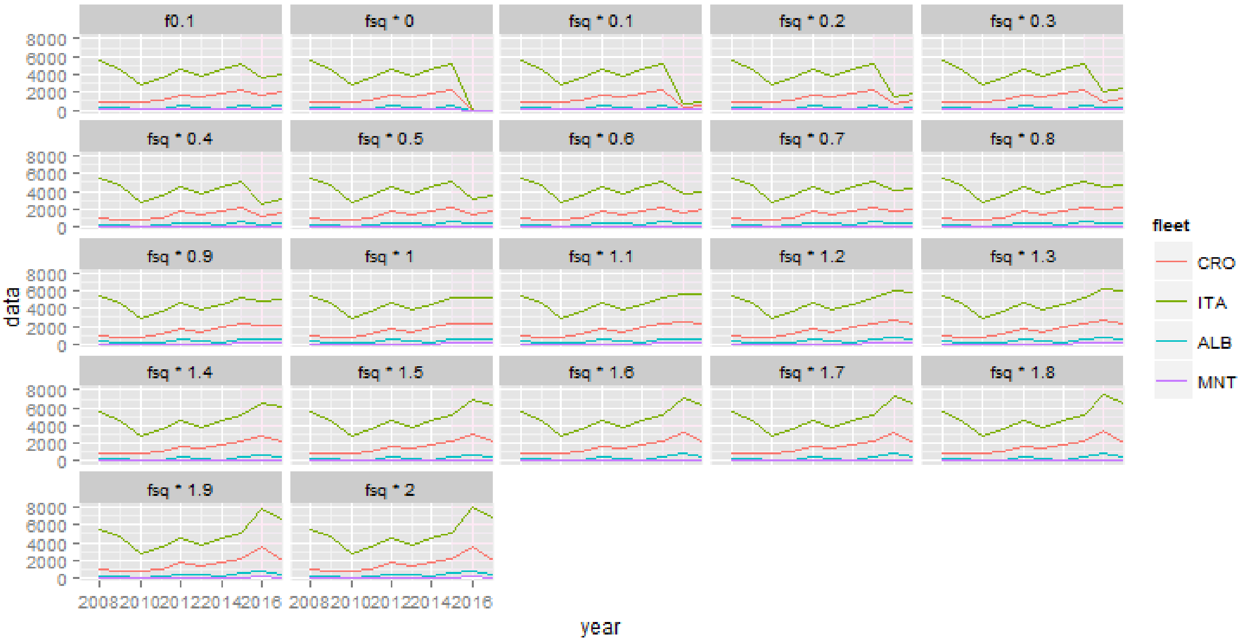


Figure 5.2.3.11.3.1. Red mullet in GSA 17 and 18. Catches by fleet at scenario from short term forecast by fleet.

Medium term predictions

Not applicable

5.2.3.1.19 Method

Not applicable

Stock advice

Considering that the $F_{current}$ = 0.54 is larger than $F_{0.1}$ = 0.41 (used as proxy of F_{MSY}), the red mullet stock in GSA 17 and 18 is exploited above F_{MSY}. A reduction of fishing mortality towards the proposed reference point is advised. Considering the overfishing situation a reduction of fishing pressure and an improvement in exploitation pattern is advisable, especially for Italian trawlers given that exploit a large amount of Age 0+ group. Catches of red mullet in 2016, consistent with $F_{0.1}$ (0.41), should not exceed 4280 tonnes.

Management strategy evaluation

An MSE was run but the results were not considered realiable. Nevertheless the F_{MSY} ranges were derived using the formula provided by STECF EWG 15-09. F ranges results were F_{upper}=0.56 and F_{lower}=0.27. B_{lim} was estimated as 3438 (t).

F_{MSY}	F_{upp}	F_{low}	B_{lim}	B_{pa}
0.41	0.56	0.27	3438	4814

5.2.4 STOCK ASSESSMENT OF RED MULLET IN GSA 19

Stock Identification

The stock of red mullet (*Mullus barbatus*) was assumed in the boundaries of the whole GSA 19. Red mullet is with hake, deep-water pink shrimp, anchovy and sardine a key species of fishing assemblages in the Ionian Sea (GSA 19) (Figure 5.2.4.1.1.).

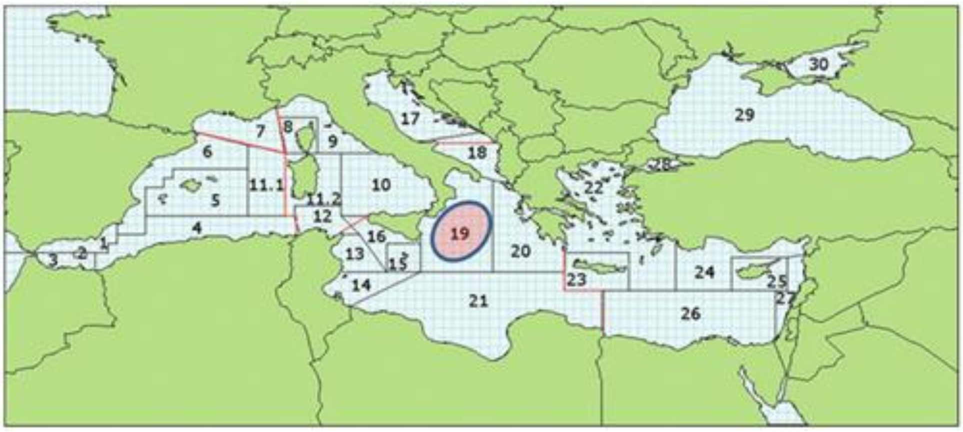


Figure 5.2.4.1.1. Geographical location of GSA 19.

Growth

In the DCF framework the growth has been studied ageing fish by otolith readings using the whole sagitta and thin sections for older individuals. DCF Von Bertalanffy growth parameters for each sex were estimated from average length at age using an iterative non-liner procedure that minimizes the sum of the square differences between observed and expected values.

The table 5.2.4.2.1 summarizes the estimated obtained by the DCF Data Call for the von Bertalanffy growth parameters and the length-weight relationship.

Table 5.2.4.2.1. Red mullet in GSA19. Summary of the estimated obtained by the DCF Data Call for the von Bertalanffy growth parameters and the length-weight relationships.

START_YEAR	END_YEAR	SEX	VB_LINF	VB_K	VB_T0	VB_SIZE_RANGE	A	B	L_W_SIZE_RANGE	
2011	2011	MUT	F	30	0.211	4-25 cm	0.0086	3.0898	6-170 g	
2014	2014	MUT	M	21.5	0.324	4-19 cm	0.0085	3.0737	5-81 g	
2007	2007	MUT	C	30	0.199	4-25 cm	0.0053	3.2862	6-85 g	
2008	2008	MUT	F	30	0.211	4-25 cm	0.0048	3.3298	6-163 g	
2014	2014	MUT	F	30	0.211	4-25 cm	0.0079	3.1062	6-134 g	
2003	2005	MUT	M	30	0.201	8-20 cm	0.0069	3.2014	NA	
2003	2005	MUT	F	33	0.221	8-22 cm	0.0083	3.1327	NA	
2014	2014	MUT	C	30	0.199	4-25 cm	0.008	3.099	1-134 g	
2013	2013	MUT	M	21.5	0.324	4-19 cm	0.0068	3.177	6-78 g	
2009	2009	MUT	C	30	0.199	4-25 cm	0.006	3.2375	2-149 g	
2006	2006	MUT	C	30	0.199	4-25 cm	0.0053	3.2862	3-163 g	
2006	2006	MUT	F	30	0.211	4-25 cm	0.0048	3.3298	6-163 g	
2006	2006	MUT	M	21.5	0.324	4-19 cm	0.0059	3.2394	6-76 g	
2007	2007	MUT	F	30	0.211	4-25 cm	0.0048	3.3298	8-85 g	
2007	2007	MUT	M	21.5	0.324	4-19 cm	0.0059	3.2394	8-65 g	
2008	2008	MUT	C	30	0.199	4-25 cm	0.0053	3.2862	3-163 g	
2008	2008	MUT	M	21.5	0.324	4-19 cm	0.0059	3.2394	6-76 g	

2009	2009	MUT	F	30	0.211	4-25 cm	0.0078	3.1436	6-149 g
2009	2009	MUT	M	21.5	0.324	4-19 cm	0.0064	3.2042	6-64 g
2010	2010	MUT	C	30	0.199	4-25 cm	0.0098	3.0472	1-120 g
2010	2010	MUT	F	30	0.211	4-25 cm	0.0109	3.0075	7-120 g
2010	2010	MUT	M	21.5	0.324	4-19 cm	0.0117	2.9749	6-77 g
2011	2011	MUT	C	30	0.199	4-25 cm	0.0081	3.1081	2-170 g
2011	2011	MUT	M	21.5	0.324	4-19 cm	0.0094	3.0457	5-85 g
2012	2012	MUT	C	30	0.199	4-25 cm	0.0091	3.0641	3-150 g
2012	2012	MUT	F	30	0.211	4-25 cm	0.0091	3.0748	7-146 g
2012	2012	MUT	M	21.5	0.324	4-19 cm	0.0096	3.0346	6-150 g
2013	2013	MUT	C	30	0.199	4-25 cm	0.0083	3.0958	1-186 g
2013	2013	MUT	F	30	0.211	4-25 cm	0.0081	3.1041	6-186 g

The observed maximum length of red mullet was 25 cm for females and 24.5 cm for males both registered in the landings (bottom long-lines).

For the present assessment, in line with the previous ones, the fast growth parameters have been used and the length weight relationship parameters as reported in the table 5.2.4.2.1.

Table 5.2.4.2.2. Red mullet in GSA 19. Growth parameters used in the present assessment.

SEX	VB_LINF	VB_K	VB_T0	A	B
C	30	0.4	-0.3	0.0072	3.168

Maturity

Size at first maturity was estimated from commercial samples using a generalized linear models (GLMs) with logistic link to describe the proportion of adult individuals on the length as independent variable (ICES, 2008). Specimens were considered adults at stage 2b (recovering), 2c (maturing), 3 (mature), 4a (spent) and 4b (resting), and immature at stage 1 (immature) and 2a (virgin developing). The estimated size at first maturity in about 12 cm for females and 11 cm for males.

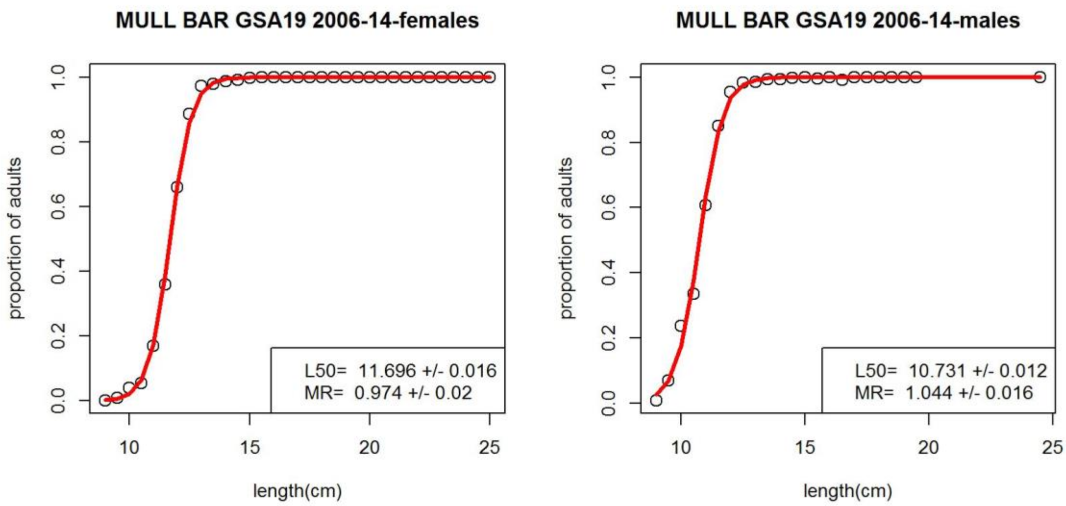


Figure 5.2.4.3.1. Red mullet in GSA 19. Proportion of mature for males and female from commercial data.

For the present assessment, in line with the assessment already done in other areas (e.g. GSA 18 and GSA 10), the fast growth parameters have been used to estimate maturity at age as reported in the table 5.2.4.3.1.

Table 5.2.4.3.1. Red mullet in GSA 19. Maturity proportion at age adopted in the present assessment.

Age	Proportion of matures
0	0.46
1	0.98
2	1
3+	1

Natural mortality

For the present assessment, in line with the previous ones, the vector of natural mortality estimated according to PRODBIOM (Abella et al., 1997) and reported in the table 5.2.4.4.1has been adopted. It is based on fast growth parameters.

Table 5.2.4.4.1. Red mullet in GSA 19. Vector of natural mortality used in the present assessment.

Age	Natural mortality
0	1.03
1	0.71
2	0.65
3+	0.62

Fisheries

5.2.4.1.1 General description of the fisheries

Red mullet is mostly targeted by trawlers (about 50% of the total production of red mullet), but also by small scale fisheries. Fishing grounds are mainly located along the coasts of the whole GSA.

5.2.4.1.2 Management regulations applicable in 2015

In Italy management regulations are based on technical measures, as closed number of fishing licenses and area limitation (distance from the coast and depth). In order to limit the over-capacity of fishing fleet, the Italian fishing licenses have been fixed since the late eighties and the fishing capacity has been gradually reduced. Other measures on which the management regulations are based regards technical measures (mesh size), minimum landing sizes (EC 1967/06).

Regarding small scale fishery management regulations are based on technical measures related to the height and length of the gears as well as the mesh size opening, minimum landing sizes and number of fishing licenses for the fleet.

Fishing closure for trawling: 45 days in late summer early autumn (not every year the same).

Cod end mesh size of trawl nets: 40 mm (stretched, diamond meshes) till 30/05/2010. From 1/6/2010 the existing nets have been replaced by a cod end with 50 mm (stretched) diamond meshes.

In 2008 a management plan was adopted, that foresaw the reduction of fleet capacity associated with a reduction of the time at sea.

5.2.4.1.3 Catches

Total catch by year is reported in table 5.2.4.5.3.1. (in term of landing and discard) and figure 5.2.4.5.3.1. Catches include the discards of OTB gear, given that discard is not present in the nets and LLS gear. Being not available in 2006-2008 and 2010, discards have been estimated on the basis of the ratio averaged in the available years.

Table 5.2.4.5.3.1. Red mullet in GSA 19. Catches in terms of landings and discards.

	2006	2007	2008	2009	2010	2011	2012	2013	2014
Landing	872	532	446	520	515	564	470	267	249
Discard (only trawlers)	5.72	3.49	2.93	9.96	3.38	0.06	3.29	0.02	1.45
Total catch	**877**	**535**	**449**	**530**	**518**	**564**	**474**	**267**	**251**

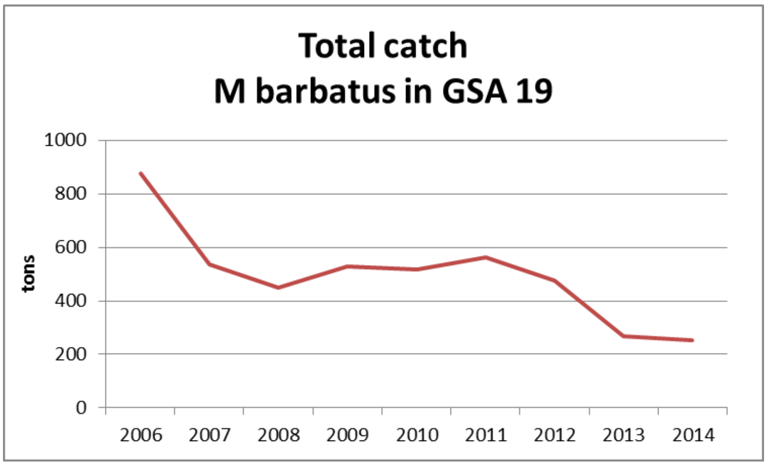


Figure 5.2.4.5.3.1. Red mullet in GSA 19. Total catch of OTB, GNS and GTR gears (tons).

For the present assessment, age distribution of red mullet (catches) in GSA 19 has been obtained as sum of landing and discard age distribution re-estimated using the knife-edge slicing method (LFDA algorithm) with the fast growth parameters used also in the assessment of red mullet in GSA 18 and GSA 10 and in the past STECF-EWG on Stock Assessments. Age distribution of catches are reported in table 5.2.4.7.2.1. and figure 5.2.4.7.2.1.

5.2.4.1.4 Landing

Available landing data are from DCF regulations. EWG 15-11 received Italian landings data for GSA 19 by fishing gears, which are listed in Table 5.2.4.5.4.1.
The landings fluctuates around 250 and 1100 tons with the maximum in 2005 and the minimum in 2014. An half part of the landings of red mullet is distributed between trawlers and a half for 20% each between nets (GNS and GTR). Landings of gears other than OTB, GNS and GTR can be considered negligible or misreporting (on average less than 1%).

Table 5.2.4.5.4.1. Red mullet in GSA 19. Annual landings (t) by major gear type, 2004-2014.

Gear	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
-1	0.1	0.0		1.0	0.5	1.4	5.6	3.0	0.1	0.7	0.4
GNS	52.0	42.8	64.7	54.7	68.5	114.1	220.0	172.9	145.9	119.2	122.8
GTR	535.0	760.3	240.9	189.5	29.3	16.1	13.1	25.0	20.8	41.3	23.7
LLD					0.4						
LLS	0.1				0.6	0.1					
OTB	363.8	297.5	566.0	287.8	348.3	389.8	283.5	371.5	309.3	110.5	102.7
PS		0.7									
PTM			0.4								
SB	0.0	6.2	7.7	4.1	0.1	4.0	7.9	8.0	3.6	1.4	0.7
SV	0.0	6.2	7.7	4.1	0.1	4.0	7.9	8.0	3.6	1.4	0.7
	951.0	**1113.7**	**887.4**	**541.1**	**447.8**	**529.5**	**538.1**	**588.4**	**483.3**	**274.4**	**251.0**

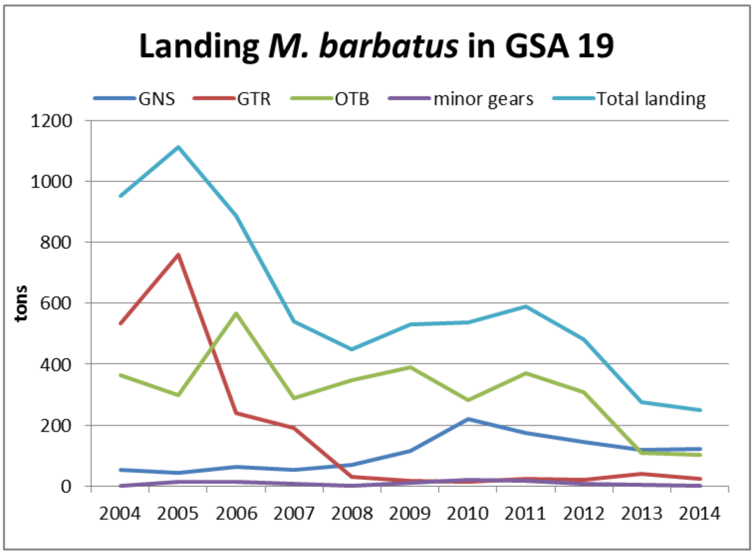


Figure 5.2.4.5.4.1. Red mullet in GSA 19. Landings by gear and total landings.

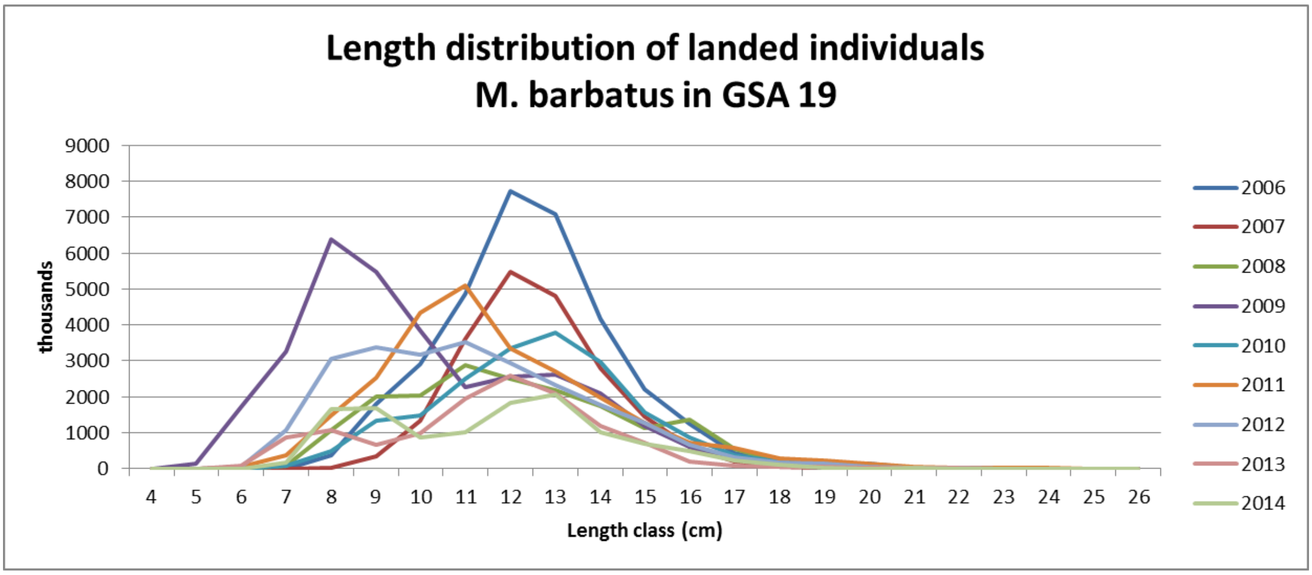


Figure 5.2.4.5.4.2. Red mullet in GSA 19. Landing distribution of red mullet.

For the present assessment, age distribution by year of red mullet (landing) in GSA 19 re-estimated with the LFDA method using the fast growth parameters are reported in figure 5.2.4.5.4.2.

Table 5.2.4.5.4.2. Red mullet in GSA 19. Landing at age (thousands) by year.

Landing at age				
Year	**0**	**1**	**2**	**3+**
2006	12510	20315	483	4
2007	7076	13527	53	0
2008	8892	8672	212	11
2009	24241	8894	177	4
2010	6973	11828	368	21
2011	14976	9536	684	64
2012	15236	8367	358	21
2013	6426	6038	170	19
2014	6006	5737	141	7

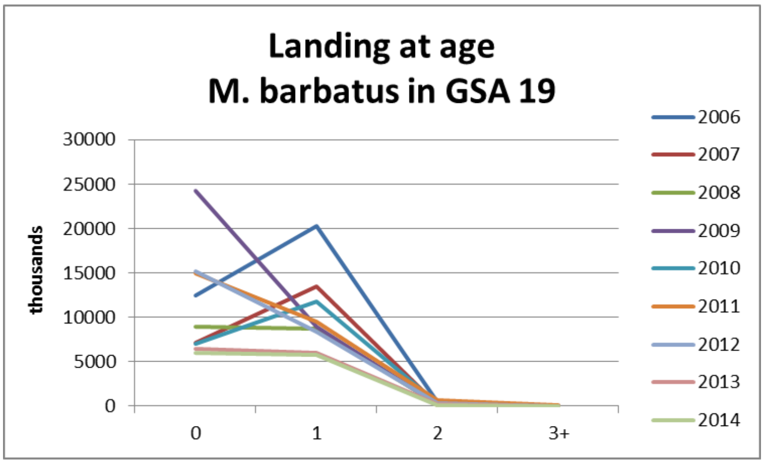


Figure 5.2.4.5.4.3. Red mullet in GSA 19. Landing at age (thousands) by year.

5.2.4.1.5 Discards

The discards of red mullet in the GSA 19 are reported for 2009, 2011-2014, as in 2007 and 2008 DCF did not foresee collection of discard data and in 2006 and 2010 the discards was not available. The volume of discards is rather variable among years, as usual for discards, but anyway discardsis in all the years no greater than 2% of the total catch. When not available the volume of discard has been estimated on the basis of the average discard ratio (D/L) in the available years.

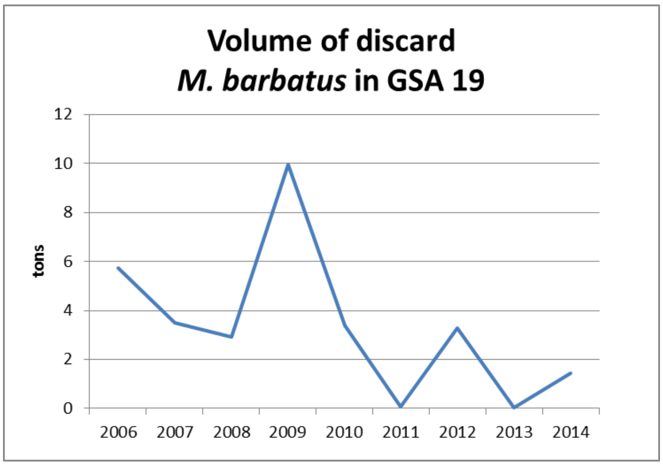


Figure 5.2.4.5.5.1. Red mullet in GSA 19. Discards by year (gear OTB).

Table 5.2.4.5.5.1. Red mullet in GSA 19. Discard at age (thousands) by year (gear OTB).

Discard at age				
Year	0	1	2	3+
2006	750.6	15.1	0	0
2007	458.1	15.1	0	0
2008	384.2	15.2	0	0
2009	1215.7	13.3	0	0
2010	443.4	15.2	0	0
2011	12.8	0.0	0	0
2012	402.1	1.3	0	0
2013	2.0	0.1	0	0
2014	309.5	0.1	0	0

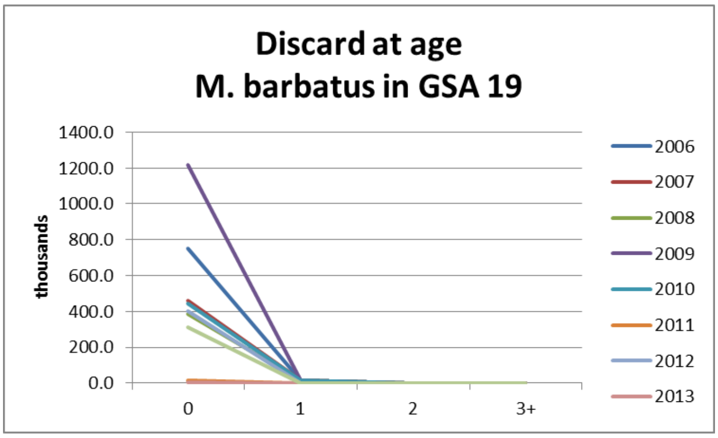


Figure 5.2.4.5.5.2. Red mullet in GSA 19. Discard at age (thousands) by year (gear OTB).

5.2.4.1.6 Fishing effort

The trends in fishing effort by fleet level and major gear type targeting red mullet in GSA 19 (blue highlitghed) are listed in tables 5.2.4.5.6.1 and 5.2.4.5.6.2 and shown in figures 5.2.4.5.6.1 and 5.2.4.5.6.2. The total fishing effort in kW*days from 2004 to 2007 is decreasing. From this year onward is variable around 17-21*10^6 kw*days.

Table 5.2.4.5.6.1. Red mullet in GSA 19. Trend in nominal fishing effort (kW*days) by fleet level from 2002-2014, DCF data.

Gear	2002	2003	2004	2005	2006	2007	2008
-1	13 116 917	9 143 878	1 418 952	1 081 525	1 776 585	1 747 956	1 126 093
FPO			378 783	56 433	54 555	43 143	232 619
GND			728 507	222 428	505 277	270 396	239 342
GNS			797 996	1 197 159	1 402 176	1 473 754	1 275 650
GTR	4 669 873	9 192 254	2 742 293	2 115 507	1 106 682	925 004	1 131 865
LLD			5 367 540	6 420 870	4 414 699	4 431 347	5 603 064
LLS			1 143 710	861 956	870 853	1 062 369	620 865
LTL				111 047	155 819	23 117	33 950
OTB	5 125 805	5 002 396	5 875 474	4 181 999	6 770 477	5 312 380	5 350 926
OTM							
PS	978 457	1 629 677	1 564 124	1 652 286	896 924	897 398	1 452 553
PTM			0		11 424		
Total	**23 891 052**	**24 968 205**	**20 017 379**	**17 901 210**	**17 965 471**	**16 186 864**	**17 066 927**

Gear	2009	2010	2011	2012	2013	2014
-1	2 427 917	3 744 421	2 058 250	540 335	420 069	410 146
FPO	306 303	284 107	166 250	270 169	153 144	133 392
GND	256 486	610 146	527 523	559 590	53 176	115 664
GNS	1 441 596	1 813 781	1 705 748	1 627 697	2 394 257	2 065 333
GTR	1 653 130	1 896 850	1 777 574	1 590 170	3 379 761	2 358 945
LLD	3 987 741	4 245 026	2 453 384	3 916 244	3 885 256	3 835 537
LLS	679 391	852 696	1 056 634	1 307 624	2 054 032	1 763 634
LTL				0		

OTB	6 361 017	6 645 697	6 832 229	6 382 671	6 128 857	6 027 003
OTM			9 781	317 792		
PS	791 024	765 213	741 056	1 014 674	615 055	511 171
PTM			13 898			
Total	**17 904 605**	**20 857 937**	**17 342 327**	**17 526 966**	**19 083 607**	**17 220 825**

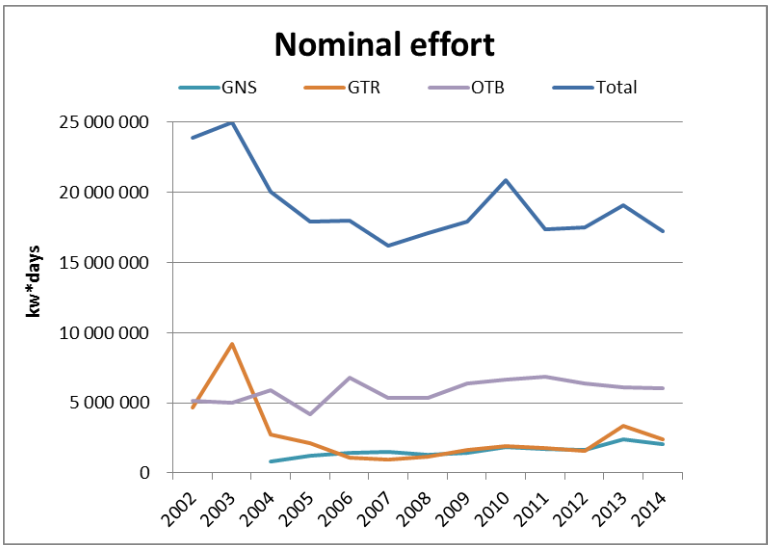


Figure 5.2.4.5.6.1. Red mullet in GSA 19. Trend in nominal fishing effort for the pulled fleet, from 2002 to 2014.

Table 5.2.4.5.6.2. Red mullet in GSA 19. Trend in GT*days at sea by fleet level from 2002-2014, DCF data.

Gear	2002	2003	2004	2005	2006	2007	2008
Miscellaneous	-1	-1	171 584	133 509	188 462	181 487	127 281
FPO			11 474	3 134	3 393	2 538	7 528
GND			39 238	26 426	46 130	27 170	20 575
GNS			78 308	101 868	123 299	123 789	98 544
GTR	-1	-1	233 891	197 023	104 406	88 113	102 936
LLD			992 388	1 086 458	806 070	804 784	892 144
LLS			110 883	69 009	68 640	89 442	64 130
LTL				9 999	14 561	1 902	3 598
OTB	-1	-1	761 067	430 253	672 536	491 942	574 366
OTM							
PS	-1	-1	208 336	190 975	132 197	109 924	184 237
PTM			820		1 478		
Total	**-1**	**-1**	**2 607 989**	**2 248 654**	**2 161 172**	**1 921 091**	**2 075 339**

Gear	2009	2010	2011	2012	2013	2014
Miscellaneous	356 898	540 555	292 749	68 756	33 284	39 523
FPO	13 909	8 993	5 670	15 718	12 862	10 551
GND	10 122	32 023	27 984	30 215	3 547	12 317
GNS	107 494	134 114	117 849	114 717	183 557	161 938
GTR	141 967	149 802	140 997	130 340	243 041	182 299

LLD	595 411	583 783	425 801	555 414	684 044	532 179
LLS	68 039	71 070	101 916	128 798	159 044	151 206
LTL				206		
OTB	711 619	760 317	805 415	785 235	621 952	615 493
OTM			1 454	43 747		
PS	81 658	82 491	111 343	139 663	83 819	75 839
PTM			3 012			
Total	**2 087 117**	**2 363 148**	**2 034 190**	**2 012 809**	**2 025 150**	**1 781 345**

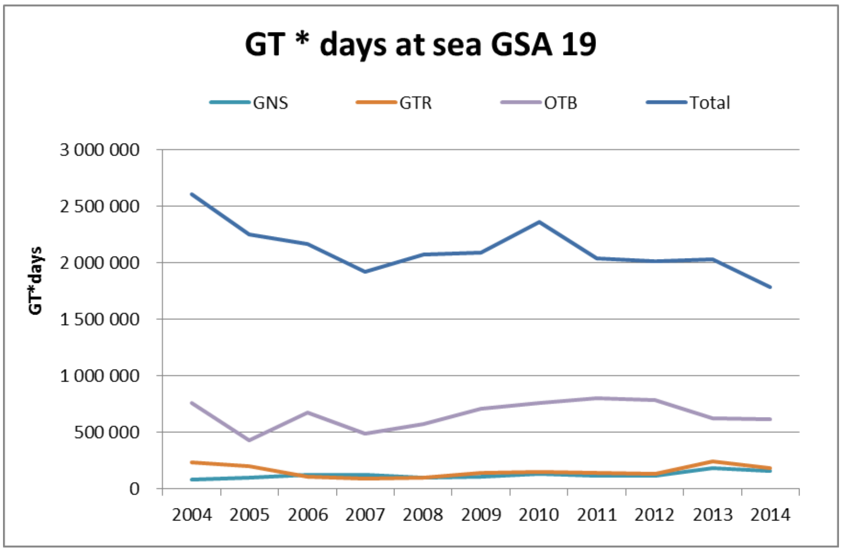


Figure 5.2.4.5.6.2. Red mullet in GSA 19. Trend in GT*days at sea for the pulled fleet, from 2004 to 2014.

Scientific surveys

5.2.4.1.7 Survey #1 (MEDITS)

5.2.4.1.7.1 Methods

According to the MEDITS protocol (Bertrand *et al.*, 2002), trawl surveys were yearly (May-July) carried out, applying a random stratified sampling by depth (5 strata with depth limits at: 50, 100, 200, 500 and 800 m; each haul position randomly selected in small sub-areas and maintained fixed throughout the time). Haul allocation was proportional to the stratum area. The same gear (GOC 73, by P.Y. Dremière, IFREMER-Sète), with a 20 mm stretched mesh size in the cod-end, was employed throughout the years. Detailed data on the gear characteristics, operational parameters and performance are reported in Dremière and Fiorentini (1996). Considering the small mesh size a complete retention was assumed. All the abundance data (number of fish per surface unit) were standardized to square kilometer, using the swept area method.

Table 5.2.4.6.1.1.1. Red mullet in GSA 19. Number of hauls per depth stratum in MEDITS trawl survey (1996-2014).

STRATUM	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2003
10 50	9	9	9	9	9	9	9	9	9	9	9

50-100	8	8	8	8	8	8	8	8	8	8	8
100-200	10	10	10	10	10	10	10	10	10	10	10
200-500	15	15	15	15	15	15	15	15	14	14	14
500-800	32	32	32	32	32	32	32	32	29	29	29
10-800	**74**	**74**	**74**	**74**	**74**	**74**	**74**	**74**	**70**	**70**	**70**

STRATUM	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
10 50	9	9	8	9	9	9	9	9	9	9
50-100	8	8	9	8	8	8	8	8	8	8
100-200	10	10	10	10	10	10	10	10	10	10
200-500	15	14	14	14	14	14	14	14	14	14
500-800	28	29	29	29	29	29	29	29	29	29
10-800	**70**	**70**	**70**	**70**	**70**	**70**	**70**	**70**	**70**	**70**

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). The density and biomass indices of red mullet in GSA19 were estimated on the depth strata 10-800 m and standardized to km^2.

The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in the GSA:

$Yst = \Sigma (Yi*Ai) / A$

$V(Yst) = \Sigma (Ai^2 * si^2 / ni) / A^2$

Where:

A=total survey area
Ai=area of the i-th stratum
si=standard deviation of the i-th stratum
ni=number of valid hauls of the i-th stratum
n=number of hauls in the GSA
Yi=mean of the i-th stratum
Yst=stratified mean abundance
V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as ± standard deviation.
It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution, quasi-poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial (e.g. O'Brien *et al*. 2004).
Length distributions represented an aggregation (sum) of standardized length frequencies distribution raised to standardized haul abundance per square km over the stations of each stratum.

5.2.4.1.7.2 Geographical distribution

The geographical distribution pattern of red mullet has been studied in the area using trawl-survey data and applying geostatistical methods.

Recently in the STOCKMED project (MAREA Framework; Fiorentino et al., 2015) biomass trends (average of the last 10 years) have been estimated (Figure 5.2.4.6.1.2.1).

If spawners are considered, the higher concentration in the GSA 19 was localised in the souther side. Recent estimations (MEDISEH Project, MAREA Framework; Giannoulaki et al., 2013) have confirmed the presence of spawning areas with persistence along time in the southern part of the GSA (5.2.4.6.1.2.2.).

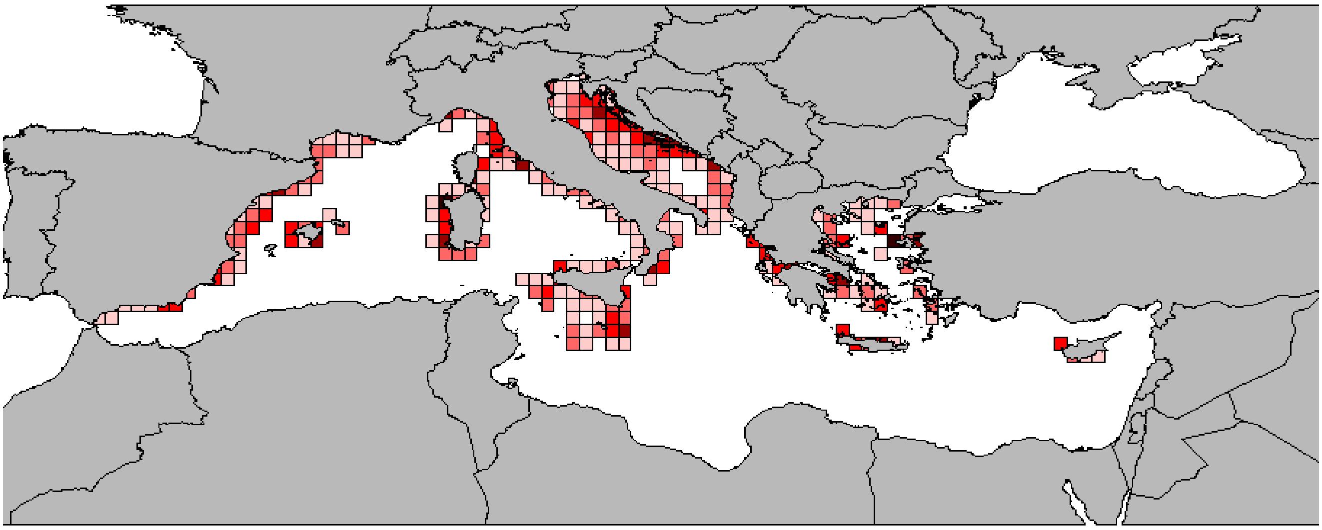


Figure 5.2.4.6.1.2.1. Red mullet in GSA 19. Geographical distribution of red mullet in the Mediterranean basin (kg/km^2), STOCKMED Project.

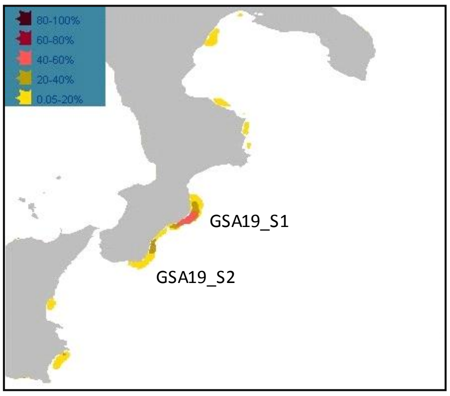


Figure 5.2.4.6.1.2.2. Red mullet in GSA 19. Spawning areas with the persistence along time, MEDISEH Project.

5.2.4.1.7.3 Trends in abundance and biomass

Fishery independent information regarding the state of the red mullet in GSA 19 was derived from the international survey MEDITS. Figure 5.2.4.6.1.3.1 displays the estimated trend of red mullet abundance and biomass indices standardized to the surface unit in the GSA19. Indices from MEDITS trawl-surveys show two important peaks in 2009 and 2014 due to an important recruitment in those years and observe quite stable values in all the time series.

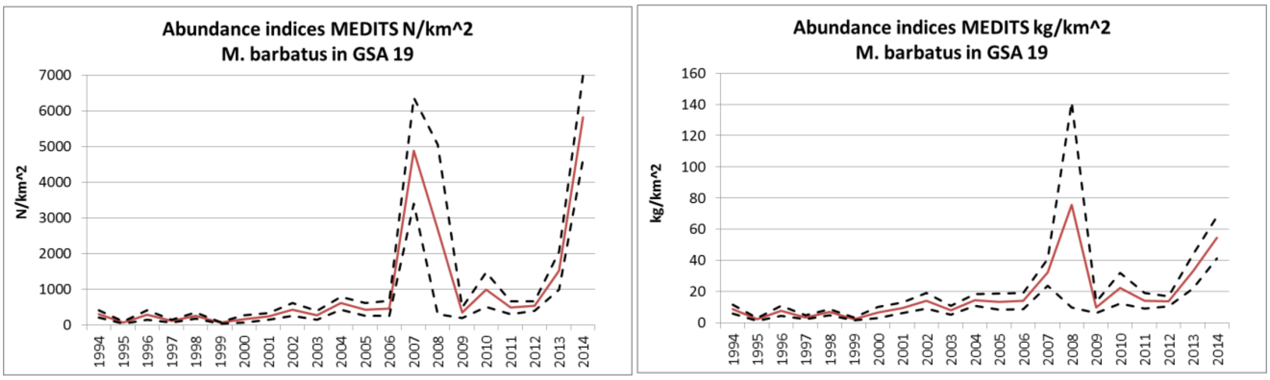


Figure 5.2.4.6.1.3.1. Red mullet GSA 19. Abundance and biomass time series of derived from MEDITS (dotted lines indicated standard deviation).

Table 5.2.4.6.1.3.1. Red mullet in GSA 19. Stratified abundance indices (N/km^2 and kg/km^2) by year, 1994-2014.

Survey	N/Km2	St. Dev	CV (%)	Kg/Km2	St.Dev	CV (%)
MEDITS 1994	302	103	34	8.80	2.95	34
MEDITS 1995	69	31	44	2.37	0.95	40
MEDITS 1996	281	132	47	7.87	3.15	40
MEDITS 1997	107	34	32	3.61	1.20	33
MEDITS 1998	260	84	32	7.01	1.94	28
MEDITS 1999	61	21	34	2.47	0.89	36
MEDITS 2000	165	98	59	6.76	3.67	54
MEDITS 2001	244	93	38	9.75	3.53	36
MEDITS 2002	432	177	41	14.22	5.14	36
MEDITS 2003	264	124	47	8.30	2.86	35
MEDITS 2004	611	180	29	14.67	3.73	25
MEDITS 2005	428	177	41	13.59	5.16	38
MEDITS 2006	460	210	46	14.07	5.12	36
MEDITS 2007	4876	1487	30	32.46	8.56	26
MEDITS 2008	2679	2378	89	75.72	65.66	87
MEDITS 2009	341	143	42	9.97	3.58	36
MEDITS 2010	987	485	49	22.34	9.77	44
MEDITS 2011	484	179	37	14.31	4.92	34
MEDITS 2012	531	134	25	13.99	3.24	23
MEDITS 2013	1511	531	35	32.99	10.77	33
MEDITS 2014	5808	1177	20	54.66	13.36	24

5.2.4.1.7.4 Trends in abundance by length or age

The following figure display the stratified abundance indices of red mullet in GSA 19 in 1994-2014.

Figure 5.2.4.6.1.4.1. Red mullet in GSA 19. Stratified abundance indices by size, 1994-2014.

Stock Assessment

5.2.4.1.8 Methods

Stock assessment has been conducted using XSA method.

The Extended Survivors Analysis (XSA – Darby and Flatman, 1994) has been used with an age range from 0 to 3+. Discard was included in the analysis. Since no discard data were available for 2006-2008 and 2010, an estimate based on the average discard ratios and discard age structures of the available years has been done. Also an estimate of the age distribution of trammel nets (GTR) in 2009 has been done.

5.2.4.1.9 Input data

For the assessment of red mullet in GSA 19 the DCF official data on the length structure has been used: no SOP correction has been applied as differences were far less than 10%. The age distribution has been estimated using the knife-edge slicing method (LFDA algorithm) with the fast growth parameters used also in the assessment of red mullet in GSA 18 and GSA 10 and in the past STECF-EWG on Stock Assessments. A sex-combined analysis was carried out.
The survey indices from MEDITS data from 2006 to 2014 have been used for the tuning. The age distribution of catches is showed in Figure 5.2.4.7.2.1 and Table 5.2.4.7.2.1. The age distribution of the tuning indices (from MEDITS survey) is reported in the Figure 5.2.4.7.2.2 and in the table 5.2.4.7.2.2.

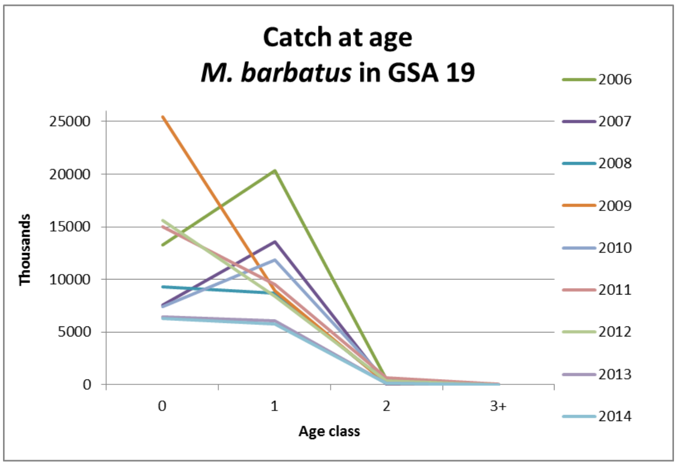


Figure 5.2.4.7.2.1. Red mullet in GSA 19. Catch (including discard) in numbers (thousands) by age and year used in the XSA.

Table 5.2.4.7.2.1. Red mullet in GSA 19. Catch (including discard) in numbers (thousands) by age and year used in the XSA.

Year	0	1	2	3+
2006	13261	20330	483	4
2007	7534	13542	53	0
2008	9276	8688	212	11

2009	25456	8907	177	4
2010	7416	11844	368	21
2011	14989	9536	684	64
2012	15638	8369	358	21
2013	6428	6038	170	19
2014	6315	5737	141	7

Table 5.2.4.7.2.2. Red mullet in GSA 19. Abundance indices (N/km^2) by age and year from MEDITS survey used in the XSA.

Year	0	1	2	3+
2006	112.75	322.08	22.89	1.79
2007	4585.87	247.98	36.74	5.77
2008	542.03	2111.15	21.95	4.20
2009	68.57	255.41	14.24	2.60
2010	475.41	491.54	18.21	1.94
2011	132.77	320.64	28.81	1.33
2012	211.44	304.83	14.20	0.72
2013	795.11	683.35	30.27	2.28
2014	5067.17	708.51	27.04	5.62

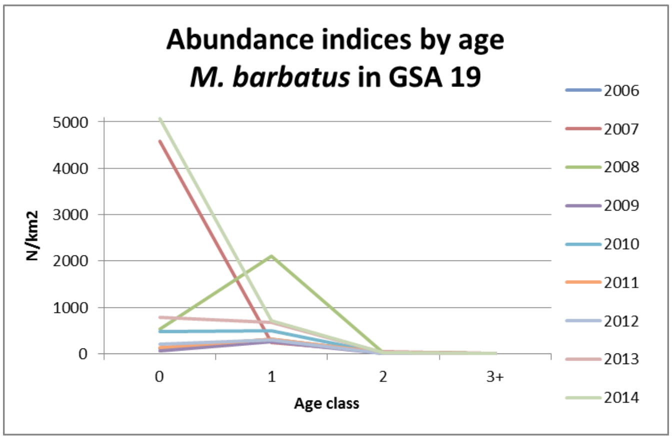


Figure 5.2.4.7.2.2. Red mullet in GSA 19. Abundance indices (N/km^2) by age and year from MEDITS survey used in the XSA.

For this assessment the fast growth parameters have been used. These, as well as maturity and natural mortality vectors, are those reported in the tables 5.2.4.2.2., 5.2.4.3.1. and 5.2.4.4.1.

In the table below are reported the mean individual weight used for the catches calculated as weighted mean of the individual weight at age from DCF weighted by the numerosity in each age class.

Table 5.2.4.7.2.3. Red mullet in GSA 19. Weights at age (kg) used in the XSA (used for the catch).

Year	0	1	2	3+
2006	0.015178	0.031216	0.089464	0.138372
2007	0.016632	0.030506	0.079099	0.147988
2008	0.012999	0.035737	0.077869	0.163862
2009	0.008814	0.033044	0.08294	0.138372
2010	0.014147	0.033012	0.085333	0.144334
2011	0.013057	0.033585	0.088681	0.151679
2012	0.011255	0.033197	0.085588	0.152988
2013	0.012285	0.030279	0.089775	0.13957
2014	0.010839	0.032787	0.08238	0.154726

In the table below are reported the mean individual weights used for the stock calculated by means of length-weight relationship (using a and b parameters from DCF) and lengths in the middle point of the age classes estimated with fast growth parameters.

Table 5.2.4.7.2.4. Red mullet in GSA 19. Weights at age (kg) used in the XSA (used for the stock).

Year	0	1	2	3+
2006	0.0054	0.0423	0.1035	0.1683
2007	0.0054	0.0423	0.1035	0.1683
2008	0.0054	0.0423	0.1035	0.1683
2009	0.0055	0.0419	0.1012	0.1634
2010	0.006	0.0407	0.0933	0.1464
2011	0.0056	0.0397	0.0926	0.1467
2012	0.0058	0.0396	0.0911	0.1434
2013	0.0056	0.0394	0.0914	0.1446
2014	0.0055	0.0383	0.089	0.1408

5.2.4.1.10Results

Several runs of XSA have been performed with the following settings:

- Proportion of F before spawning = 0
- Proportion of M before spawning = 0
- Minimum standard error (mse) for population estimates derived from each fleet = 0.3.
- shk.n=TRUE, shk.f=TRUE, shk.yrs=3, shk.ages=2

Sensitivity analysis has been performed varying the following settings:

- Catchability (rage) independent on stock size for all ages = 0, 1 and -1
- Catchability (qage) independent of age for ages > 0, 1 and 2
- Shrinkage of the mean (fse) = 0.5, 1, 1.5 and 2

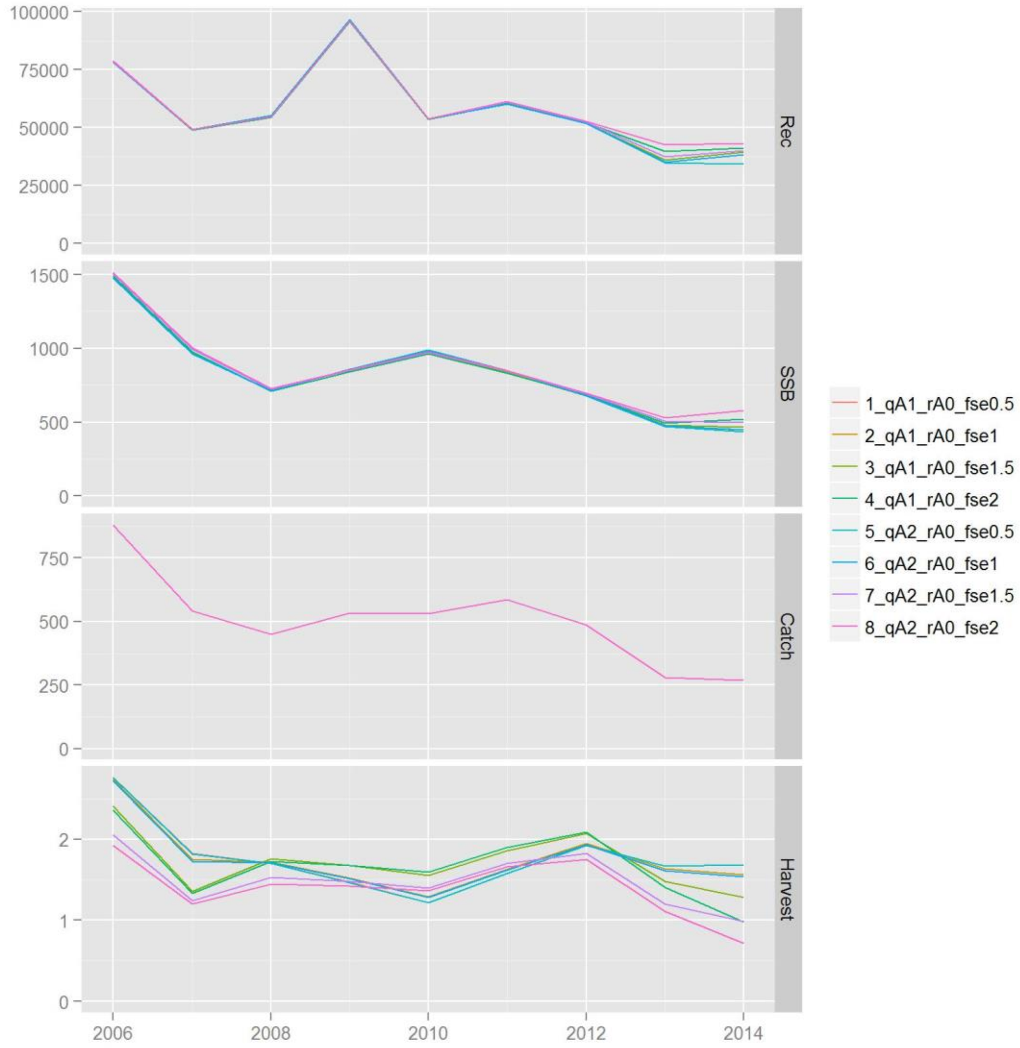


Table 5.2.4.7.3.1. Red mullet in GSA 19. Plot of the stock parameters estimated by the best 8 XSA runs.

In Table 5.2.4.7.3.1. are reported minimum, maximum and average values of residuals for the 8 runs with the lower average residuals of absolute values.

Table 5.2.4.7.3.1. Red mullet in GSA 19. Residual values for the best 8 XSA runs.

run	minimum	maximux	average_abs_values
8_qA2_rA0_fse2	-0.603	1.904	0.226
4_qA1_rA0_fse2	-0.708	1.845	0.26
7_qA2_rA0_fse1.5	-0.705	1.827	0.269
3_qA1_rA0_fse1.5	-0.802	1.761	0.321
6_qA2_rA0_fse1	-0.965	1.791	0.475
2_qA1_rA0_fse1	-1.116	1.648	0.491
5_qA2_rA0_fse0.5	-1.103	2.021	0.517
1_qA1_rA0_fse0.5	-1.302	1.823	0.53

The run with catchability (rage) independent on stock size for all ages = 0, the catchability (qage) independent of age for ages > 2 and shrinkage of the mean (fse) = 1.5 has been chosen on the basis of the residuals and of the retrospective analysis.

The log-catchability residuals at age and the retrospective analysis results are shown in Figure 5.2.4.7.3.2 and Figure 5.2.4.7.3.3.

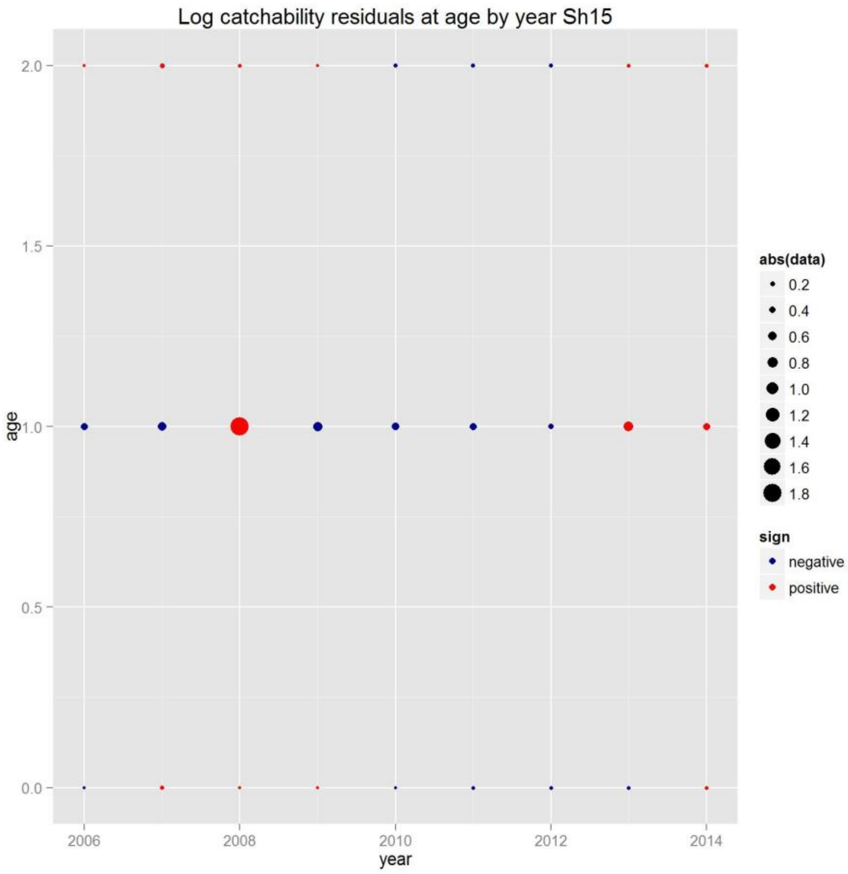


Figure 5.2.4.7.3.2. Red mullet in GSA 19. Log-catchability residuals at age for the tuning index.

The residuals do not show any trend and overall the absolute values are low. The retrospective analysis shows also a consistent pattern.

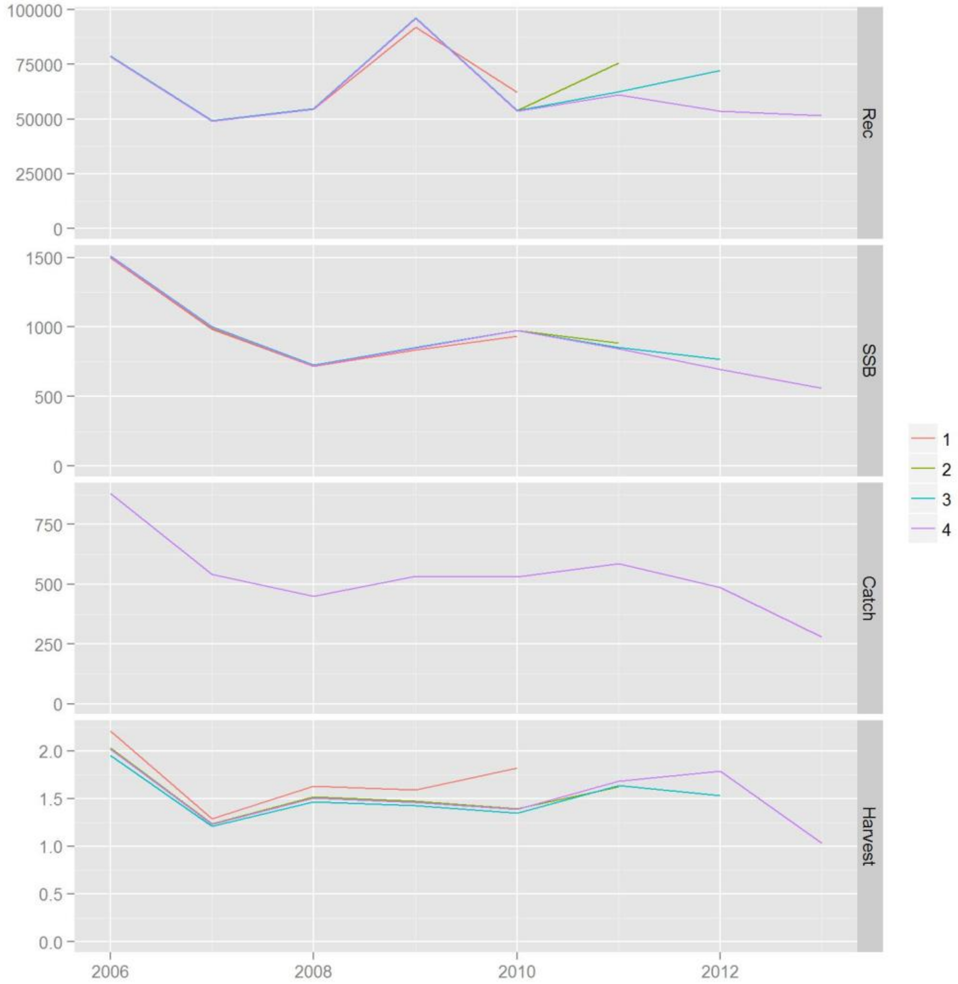


Figure 5.2.4.7.3.3. Red mullet in GSA 19. Retrospective analysis (2010-2013).

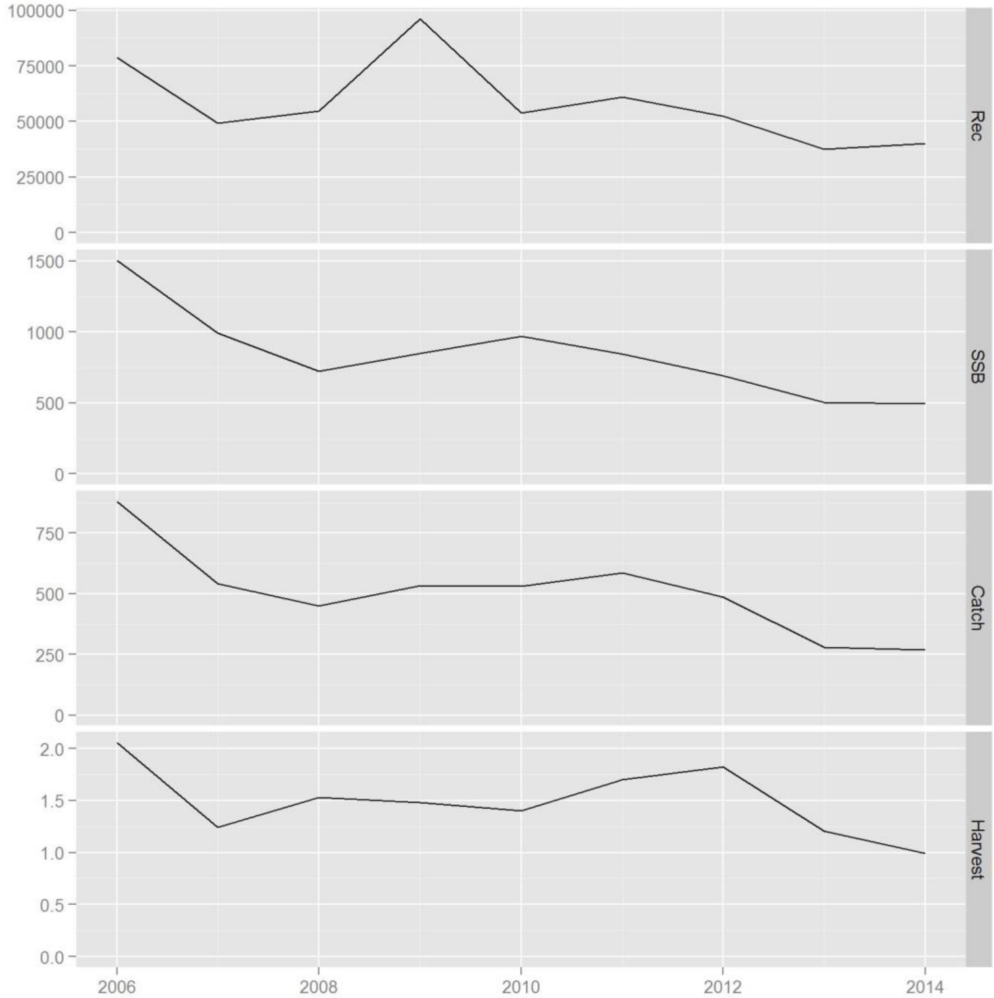


Figure 5.2.4.7.3.4. Red mullet in GSA 19. XSA results in terms of recruitment, SSB, Catches and fishing mortality.

The F_{bar} along the time series is on average 1.49, with a minimum of 0.99 in 2014 and a maximum of 2.05 in 2006 (Table 5.2.4.7.3.2). The recruitment show a peak in 2009 equal to 96134 thousands individuals and after that year slightly decreases until 2014 (40112 thousands). The SSB showed a decreasing trend, even if in 2010 it increased again to a value equal to 972 t and again decrease until 2014 reaching the lower value of the time series (496 t).

Table 5.2.4.7.3.2. Red mullet in GSA 19. Fishing mortality at age by year, $F_{bar(0-2)}$, spawning stock biomass (SSB, t) and Recruitment (R, thousands) estimated with XSA.

Year	F age 0	F age 1	F age 2	F age 3+	Fbar (0-2)	SSB (t)	R (thousands)
2006	0.33	3.75	2.08	2.08	2.05	1506	78635
2007	0.30	3.18	0.24	0.24	1.24	993	49142
2008	0.33	3.00	1.25	1.25	1.53	722	54595
2009	0.59	2.42	1.45	1.45	1.48	850	96134
2010	0.26	2.15	1.79	1.79	1.40	972	53719
2011	0.53	2.55	2.02	2.02	1.70	845	60974
2012	0.69	2.68	2.11	2.11	1.83	693	52477

2013	0.34	2.49	0.79	0.79	1.20	505	37481
2014	0.31	1.95	0.71	0.71	0.99	496	40112

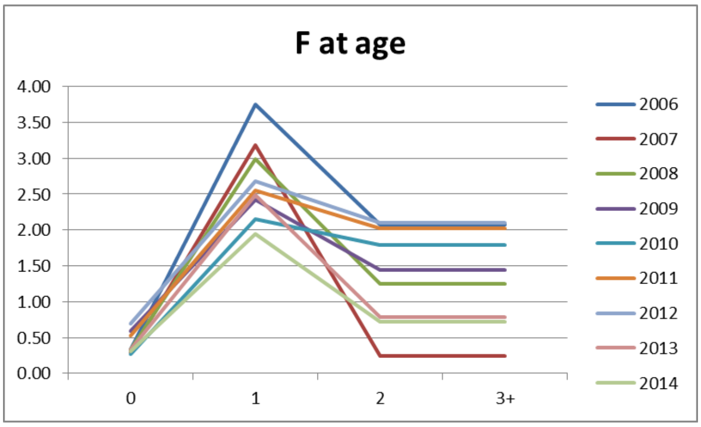


Figure 5.2.4.7.3.5. Red mullet in GSA 19. Fishing mortality at age by year estimated with XSA.

Reference points

5.2.4.1.11 Methods

To predict the effect of changes in fishing effort of future yields and to define reference points F_{01} (as a proxy for F_{MSY}) and F_{max} a Yield per Recruit analysis (YPR) was carried out in R.

5.2.4.1.12 Input data

As input the same population parameters used for the XSA and its output of the exploitation pattern were used.

5.2.4.1.13 Results

The reference points calculated with FLBRP package are shown in table 5.2.4.8.3.1.

Table 5.2.4.8.3.1. Reference Points estimated on the $F_{bar(0-2)}$ using XSA.

F	Total Yield	Recruitment	SSB	Biomass
0.45	438	55796	1440	1623

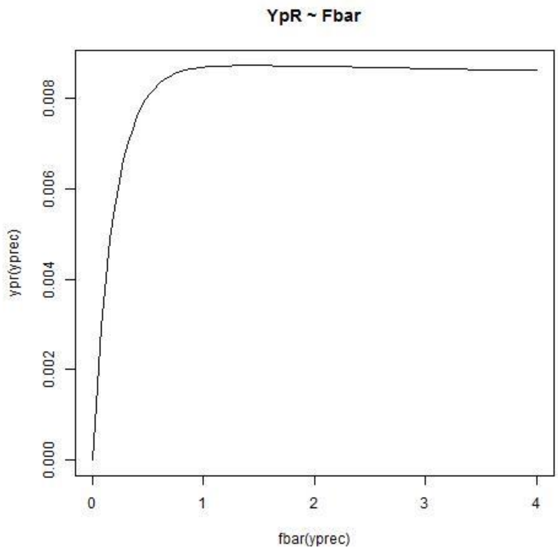


Figure 5.2.4.8.3.1. Red mullet in GSA 19. Yield per Recruitment, XSA.

In the table below are reported the following reference points calculated from F_{msy} = 0.45.

Table 5.2.4.8.3.2. F_{upper}, F_{lower}, B_{lim} and B_{pa} calculated from F_{msy} = 0.45.

F_{upper}	F_{lower}	B_{lim}	B_{pa}
0.62	0.30	496	695

Data quality

Data from DCF 2015 were used. A difference in the sum of products compared to landings was always far less than 10%. Discards data of 2009 and 2011 to 2014 were available. Information on number of samples for landings, discards and catches, as well as the number of measurements by length for landings, discards and catches were also available. Number of otoliths was also available. MEDITS raw data used for this assessment have been processed by the expert using the software FishTrawl. Growth, maturity by length and age and sex ratio were available for the whole time series (2002-2014).

Short term predictions 2015-2017

5.2.4.1.14 Method

A deterministic short term prediction for the period 2015 to 2017 was performed using the FLR routines provided by JRC, which takes into account the catch and landings in numbers and weight and the discards. This routine performs short terms for the whole fleet.

5.2.4.1.15 Input parameters

The same input parameters used in the XSA analysis shown above were used. Different scenarios of constant harvest strategy with F_{bar} calculated as the average of ages 0 to 2 and F status quo (F_{stq} = 1.424; geometric mean of the last three years) were performed. Recruitment (class 0) has been estimated from the population results from the geometric mean of the last three years 2012-2014 (43937 thousands individuals) estimated using XSA.

5.2.4.1.16 Results

The results of the short term forecasts related to the whole fleet are summarised in the table 5.2.4.10.3.1.

Table 5.2.4.10.3.1. Short term forecast in different F scenarios computed for red mullet in GSA 19. Basis: F(2015) = mean(F_{bar}0-2 2012-2014)= 1.3; R(2014) = geometric mean of the recruitment of the last 3years = 42889 (thousands); SSB(2014) = 496 t, Catch (2014)= 269 t.

Rationale	Ffactor	Fbar	Catch 2016	Catch 2017	SSB 2017	Change SSB 2016-2017(%)	Change Catch 2014-2016(%)
zero catch	0	0	0	0	1190	113.2	-100.0
High long-term yield (F0.1)	0.34	0.44	187	269	855	53.3	-30.7
Status quo	1	1.30	377	374	553	-1.0	40.2
Different scenarios	0.1	0.13	66	114	1069	91.5	-75.6
	0.2	0.26	122	195	968	73.5	-54.8
	0.3	0.39	170	252	884	58.4	-36.8
	0.4	0.52	212	293	813	45.6	-21.3
	0.5	0.65	248	321	752	34.8	-7.7
	0.6	0.78	281	341	700	25.5	4.2
	0.7	0.91	309	355	656	17.5	14.7
	0.8	1.04	334	364	617	10.5	24.1
	0.9	1.17	357	370	583	4.4	32.5
	1.1	1.43	396	377	526	-5.8	47.1
	1.2	1.56	413	378	501	-10.1	53.4
	1.3	1.68	429	379	480	-14.0	59.3
	1.4	1.81	443	379	460	-17.6	64.7
	1.5	1.94	457	379	441	-20.9	69.7
	1.6	2.07	469	379	425	-23.9	74.3
	1.7	2.20	481	378	409	-26.7	78.7
	1.8	2.33	492	377	395	-29.3	82.8
	1.9	2.46	503	377	381	-31.7	86.7
	2	2.59	513	376	369	-34.0	90.4

A short term projection of the whole fleet (table 5.2.4.10.3.1), assuming an Fstq of 1.3 in 2014 and a recruitment of 42889 thousands individuals (geometric mean on last 3 years) shows that:

- Fishing at the Fstq (1.3) generates a increase of the catch of 40.2% from 2014 to 2016 along with an approximately stable spawning stock biomass (change -1%) from 2016 to 2017.
- Fishing at F0.1 (0.34) generates a decrease of the catch of 30.7% from 2014 to 2016 and an increase of the spawning stock biomass of 53.3% from 2016 to 2017.

Short term predictions 2015-2017 by fleet

A deterministic short term prediction for the period 2015 to 2017 was performed using the FLR routines (stf.r) provided by JRC, which takes into account the catch and landings in numbers and weight and the discards. This routine performs short terms for the whole fleet.

A generic approximate multifleet projections with FLR provided by JRC was also used to split the fishing mortality by fleet using proportion of catch in number by age and fleet.

5.2.4.1.17 Method

5.2.4.1.18 Input parameters

The same input parameters used in the XSA and in the short term predictions 2015-2017 on the overall fleet have been used to parameterize: F_{bar} calculated as the average of ages 0 to 2, F status quo = 1.3 (geometric mean of 2012-2014), recruitment (class 0) = 42889 thousands individuals (geometric mean of 2012-2014).

5.2.4.1.19 Results

Results of the short term multifleet projections are reported in the table 5.2.4.11.3.1 and Figure 5.2.4.11.3.1.

Table 5.2.4.11.3.1. Red mullet in GSA19. Fishing mortality by fleet, STF.

Fbar 0-2	2006	2007	2008	2009	2010	2011	2012	2013	2014	Mean of last three years
Nets	0.91	0.53	0.30	0.43	0.46	0.78	0.56	0.73	0.60	0.63
Trawls	1.14	0.71	1.23	1.05	0.94	0.92	1.27	0.48	0.39	0.71
Overall	2.05	1.24	1.53	1.48	1.40	1.70	1.83	1.20	0.99	1.34

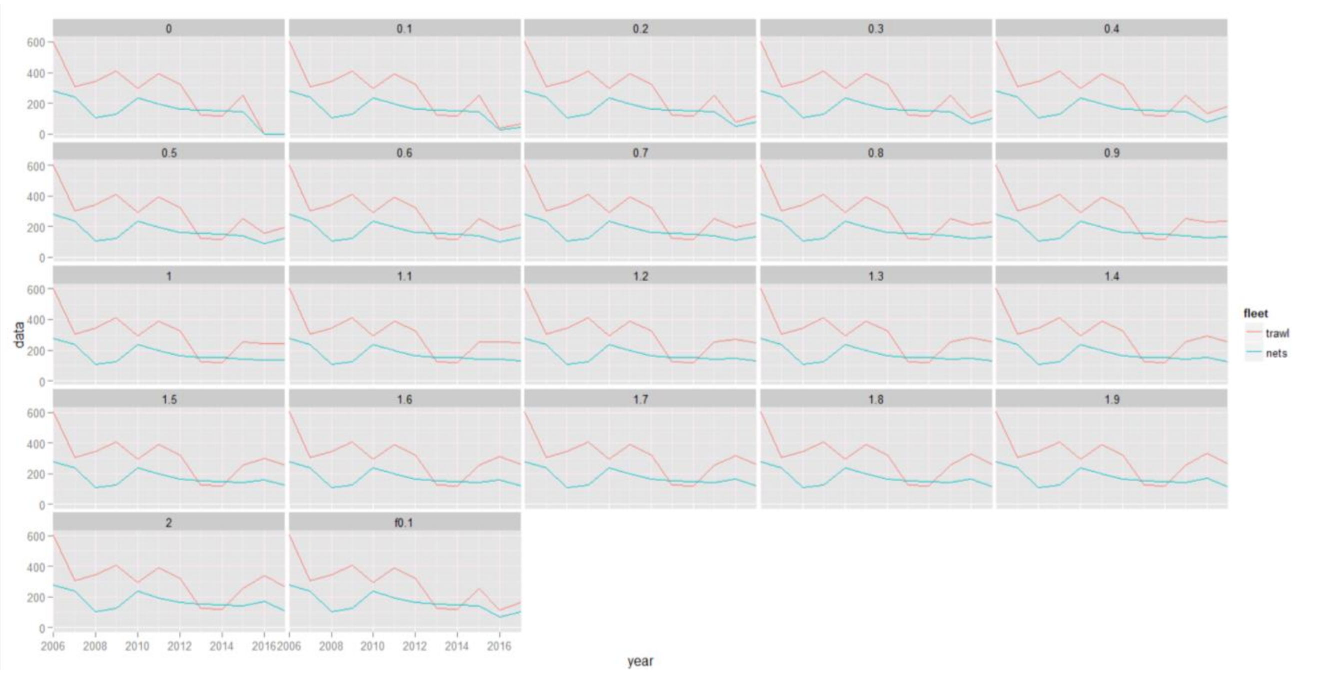


Figure 5.2.4.11.3.1. Red mullet in GSA 19. Short term forecast by fleet.

Table 5.2.4.11.3.2. Red mullet in GSA 19. Predicted catches by fleet.

	Zero catch			Status quo			High long-term yield (F0.1)		
	2015	**2016**	**2017**	**2015**	**2016**	**2017**	**2015**	**2016**	**2017**
nets	142	0	0	142	134	133	142	70	105
trawl	254	0	0	254	243	242	254	116	164
Overall	396	0	0	396	377	374	396	187	269

Medium term predictions 2015-2017 by fleet

5.2.4.1.20 Method

Medium terms predictions were not carried out, as a stock recruitment relationship was not available.

Stock advice

STECF-EWG 15-11 proposes $F_{0.1}$=0.45 as limit management reference point consistent with high long term yield and lower risk of stock collapse.

SSB and recruitment show a decreasing trend from 2010 and the F and the catches from 2012, as well. According to the F estimates obtained using landing, discard data and survey indices in XSA, in the last year of the time series (2014) F_{curr} (0.99) was above the estimated reference value of $F_{0.1}$=0.45.

The $F_{current}$ is equal to 0.99. This value is larger than $F_{0.1}$ (0.45), chosen as proxy of F_{MSY} and as the exploitation reference point consistent with long term yields (F_{MSY}), which indicates that the stock of red mullet in GSA 19 is being fished above F_{MSY}. Catches of red mullet in 2016 consistent with $F_{0.1}$ (0.45) would not exceed 187 tonnes.

Management strategy evaluation

F ranges results were F_{upper}=0.62 and F_{lower}=0.3. Blim (496 t) was estimated as was estimated as the minimum SSB estimated in XSA assessment. The Management Strategy Evaluation was ran to evaluate if the MSY ranges were precautionary. The F_{MSY} ranges were derived using the formula provided by STECF 15-09. The management strategy evaluation included uncertainty in the recruitment around a mean level resulting from the geometric mean of the last 3 years of data and uncertainty in the MEDITS. The stock was assessed by XSA, with the same settings of the assessment at each iteration. The number of iterations was 250. The following figure 5.2.4.14.1 shows the evolution of the main four stock indicators. The probability of SSB falling below B_{lim} fishing at F_{upper} was estimated at 0. Assuming that projection has stabilised the SSB in final year (2037) is 1171, the fishing mortality is 0.64 and recruitment is 53719 thousands individuals.

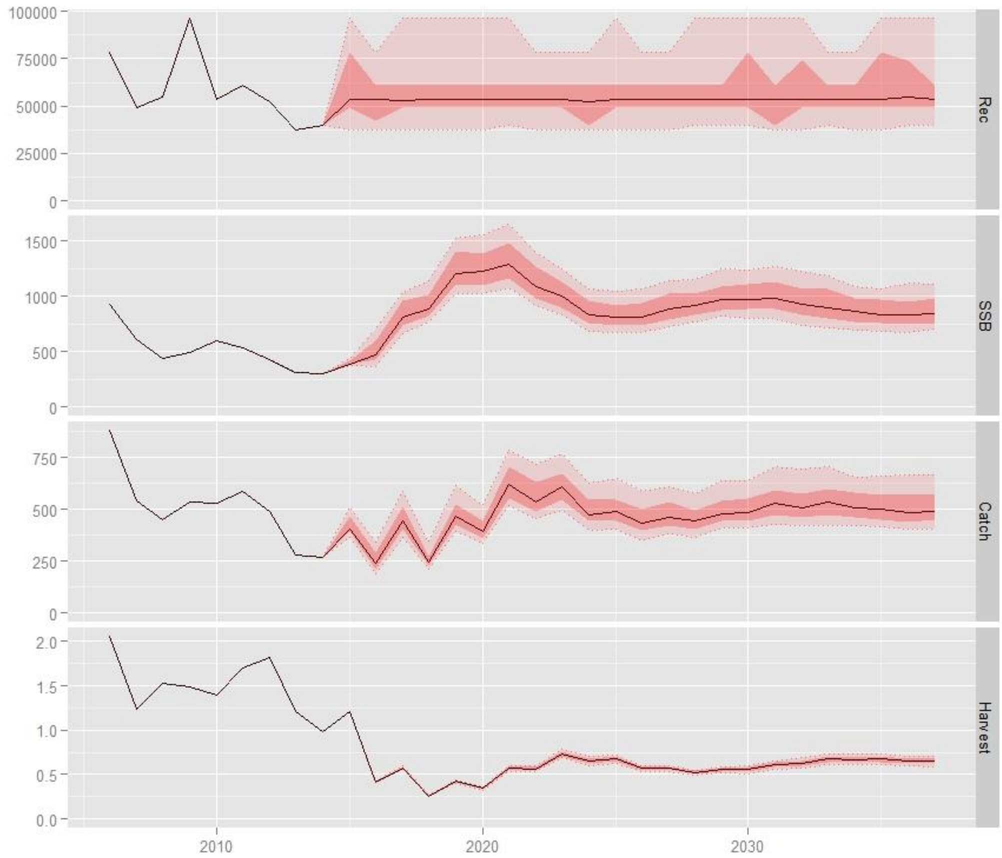


Figure 5.2.4.14.1. Red mullet in GSA 19. Projection of recruitment, spawning stock biomass, landings and fishing mortality for the period 2015 – 2037 based on a management strategy.

5.2.5 STOCK ASSESSMENT OF COMMON SOLE IN GSA 17

Stock Identification

S. solea is a demersal and sedentary species (Figure 5.2.5.1.1), living on sandy and muddy bottoms (Tortonese, 1975, Fisher et al., 1987, Jardas, 1996). Although Jardas (1996) stated that the species is distributed from coastal waters to 250 m depth, it was exclusively caught up to 100 m during the MEDITS expedition in 1996-1998 (Vrgoč, 2000).

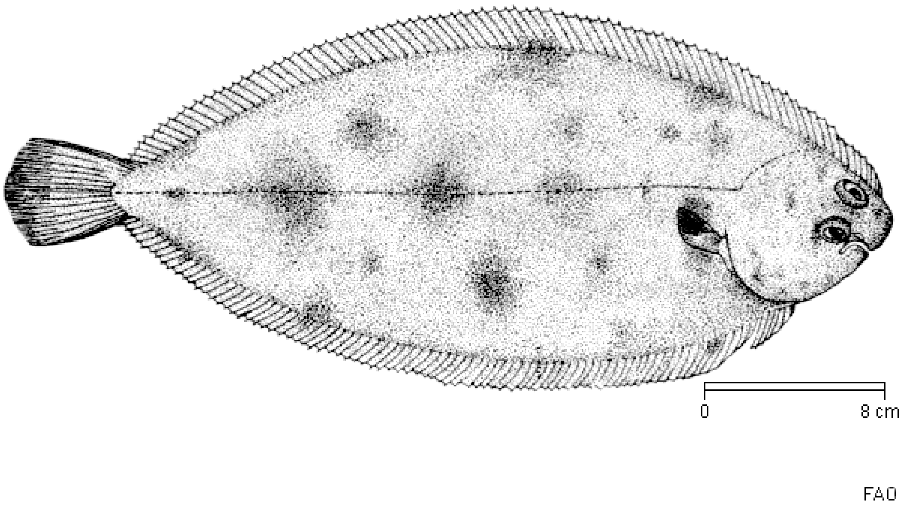


Figure 5.2.5.1.1. Common sole in GSA 17. Specimen of *Solea solea* (source: www.fishbase.org).

Common sole usually feeds very often on small quantities of prey (Sà et al., 2003). This suggests a high evacuation rate between the stomach and the intestine, and a lack of digestion in the stomach (Lagardère, 1987). The fish feeds night and day and for the remaining time usually lives embedded in the seabed. In the Adriatic Sea food items mostly include invertebrates and small fish (Tortonese, 1975; Fisher et al., 1987; Jardas, 1996). Within the framework of SoleMon project, a study of gut content using carbon- and nitrogen stable isotopes along the sole food web was carried out, indicating that *S. solea* diet depends on both the geographical position and the size of soles, which change their feeding habit with the increase of the age. This could be related to the fact that the sole selects its preys based on both their energetic value and the energy spent to catch them. The choice of sole would be also related to prey abundance, as postulated by the "optimal foraging theory" (MacArthur and Pianka, 1966) and observed in other flatfish (Hinz et al., 2005). Stergiou and Karpouzi (2002) found that in the Mediterranean Sea the sole increases its trophic level as it increases in size, reaching values around 3.4. The mean trophic level estimated from the SoleMon project data through the stable isotope analysis was slightly higher (3.9), but similar to the value obtained in a study carried out in the mouth of the river Rhone (Darnaude, 2005).

Tagging experiments carried out on common sole in the northern Adriatic Sea, using the traditional mark-and-recapture procedure, showed that all individuals were re-captured within the sub-basin (Pagotto et al., 1979). Local currents, eddies and marked differences of oceanographic features of this sub-basin with respect to those of southern Adriatic and Ionian Sea (Artegiani et al., 1997) may prevent a high rate of exchange of adult spawners and the mixing of planktonic larval stages from nursery areas of adjacent basins (Magoulas et al., 1996). Guarnieri et al. (2002), taking into account differences of sole specimens from five different central Mediterranean areas in the control region sequence marker, suggested that two near-panmictic populations of common sole could exist in the Adriatic Sea. The former population would inhabit the entire GSA 17 (northern Adriatic Sea). The

second unit seems to be spread along the Albanian coasts (eastern part of the GSA 18). The hydrogeographical features of this semi-enclosed basin might support the overall pattern of differentiation of the Adriatic common soles.
The northern Adriatic Sea has a high geographical homogeneity, with a wide continental shelf and eutrophic shallow-waters. The southern Adriatic in contrast, is characterized by narrow continental shelves and a marked, steep continental slope (1200 m deep; Adriamed, 2000). This deep canyon could represent a significant geographical barrier for S. solea.
On these bases, different actions for fishery management should be proposed for the Adriatic common sole stocks in GSA 17 and GSA 18. In the former area the stock is shared among Italy, Slovenia and Croatia, while in the latter one seems to be shared only between Montenegro and Albania (Figure 5.2.5.1.2).
A study supported by ADRIAMED-FAO (SoleDiff), about the population structure of common sole in the Adriatic Sea, confirmed the previous evidences about the genetic differentiation between the stocks in GSA 17 and GSA 18. Capitalizing on an available dataset of 353 *S. solea* individuals sequenced in previous projects, additional sequences for 62 individuals of *S. solea* that were collected during the SoleMon survey in 2007 in the eastern side of GSA18 (Albania and Montenegro) and 9 from GSA17 have been generated. The analyses of the Adriatic populations showed a low but significant differentiation between GSA 17 and GSA 18 populations, with a stronger gene flow from the GSA 18 to the GSA 17.

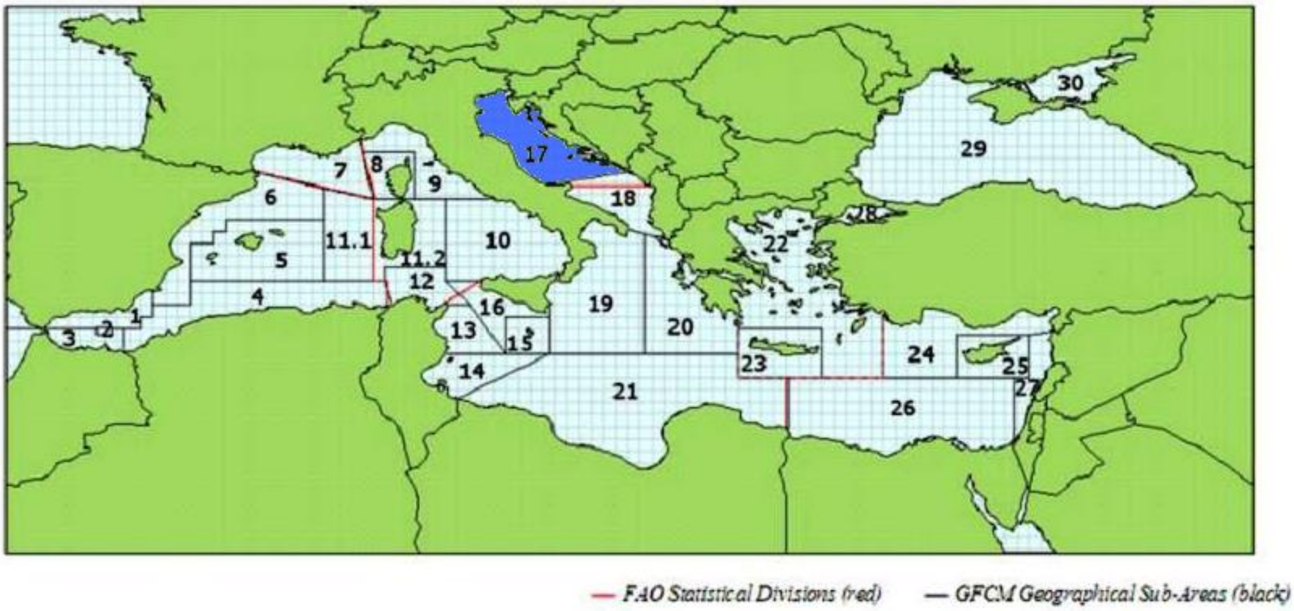


Figure 5.2.5.1.2. Geographical localization of GSA 17.

Growth

In the Adriatic sea, growth analyses on this species have been made using otoliths, scales and tagging experiments. A great variability in the growth rate was noted: some specimens had grown 2 cm in one month, while others, of the same age group, needed a whole year (Piccinetti and Giovanardi, 1984). Von Bertalanffy growth equation parameters have been calculated using various methods. Within the framework of SoleMon project, growth parameters of sole were estimated through the length-frequency distributions obtained from surveys (Tab. 5.2.5.2.1., Tab. 5.2.5.2.2. and Figure 5.2.5.2.1.). Growth parameters were available from Italy and Croatia from the 2015 DCF official data call.

Table 5.2.5.2.1. Common sole in GSA 17. Growth rates from different studies. (TL, cm; age, yr).

Author	**Sex**	**Age**					
		1	**2**	**3**	**4**	**5**	**6**
Ghirardelli (1959)	M+F	16.8	21.4	23.9	25.6	33.1	-
Piccinetti and Giovanardi (1984)	M+F	18-20	21-30	-	-	-	-
Vallisneri *et al.* (2000)	F	20	25	29	32	34	37

Table 5.2.5.2.2. Common sole in GSA 17. Von Bertalanffy parameters estimated in different studies. *(k, yr--1; t0, yr).

Author	**Sex**	**W∞ (g)**	**L∞ (cm)**	**k (month-1)**	**t_0 (month)**
Piccinetti and Giovanardi (1984)	M+F	-	40.10	0.68*	-
Froglia and Giannetti (1985)	M+F	-	38.25	0.041	-3.57
Froglia and Giannetti (1986)	M	323	23.20	0.069	-1.66
	F	562	37.87	0.042	-5.36
	M+F	576	38.25	0.041	-3.57
Fabi *et al.* (2009)	M+F	-	39.60	0.44*	-0.46*
DCF 2015 data call Italy	M+F		32.028	0.785	-0.714
DCF 2015 data call Croatia	M+F		38.25	0.041	-3.57

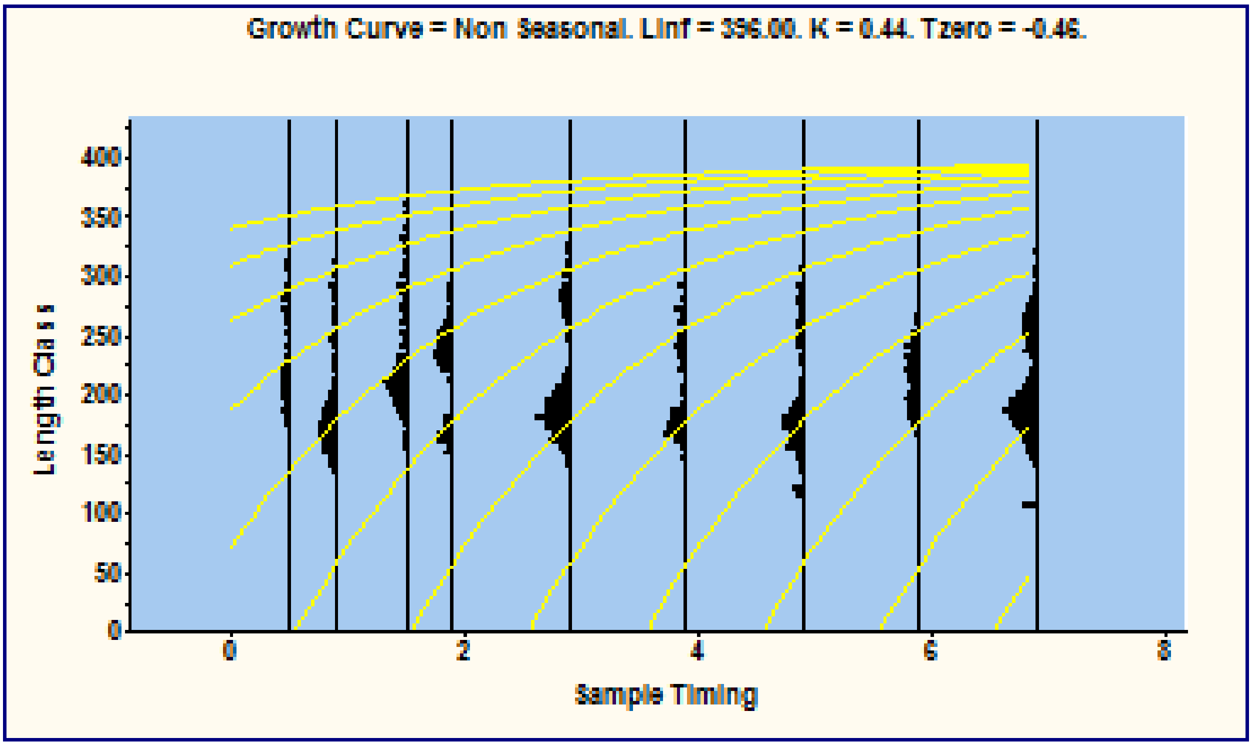


Figure 5.2.5.2.1. Common sole in GSA 17. Von Bertalanffy growth functions estimated for the GSA 17, based on SoleMon length frequency distributions (2005-2012).

Maturity

In the Mediterranean Sea, the reproduction of common sole occurs from December to May (Bini; 1968-70), Tortonese, 1975, Fisher et al., 1987). Within the framework of SoleMon project, it has been observed that in the central and northern Adriatic Sea the reproduction takes place from November to March. Data on the spatial distribution of spawners provided by the project show a higher concentration of reproducers off the western coast of Istria (Fabi et al., 2009).

Length at first maturity is 25 cm (Fisher et al., 1987; Jardas, 1996; Vallisneri et al., 2000); this value has been estimated at 25.8 using data from SoleMon project. The proportion of mature by age estimated by SoleMon data is presented in table 5.2.5.6.2.1.

Females having a weight of 300 g have about 150,000 eggs, while those weighting 400 g have about 250,000 eggs (Piccinetti and Giovanardi, 1984); eggs are pelagic. The male-female ratio is approximately 1:1 (Piccinetti and Giovanardi, 1984; Fabi et al., 2009).

Hatching occurs after eight days and the larva measures 3 to 4 mm TL (Tortonese, 1975). Eye migration starts at 7 mm TL and ends at 10-11 mm TL. Benthic life begins after seven or eight weeks (15 mm) in coastal and brackish waters (Bini (1968-70); Fabi et al., 2009).

Fisheries

5.2.5.1.1 General description of the fisheries

The common sole is a very important commercial species in the central and northern Adriatic Sea (Ghirardelli, 1959; Piccinetti, 1967; Jardas, 1996; Vallisneri et al., 2000; Fabi et al., 2009). Italian rapido trawlers exploit this resource, usually providing more than 40% of landings. Sole is also a target species of the Italian and Croatian set netters, and it represents an accessory species for otter trawlers.

From censuses carried out at the landing sites, the Italian rapido trawl fleet operating in GSA 17 was made of 155 vessels in 2005 and 124 vessels in 2006 ranging from 9 to 30 m in vessel length. GRT ranged from 4 to 100 and the engine power from 60 to 1000 HP. Each vessel can tow from 2 to 4 rapido trawls depending on its dimensions. The rapido trawl is a gear used specifically for catching flatfish and other benthic species (e.g. cuttlefish, mantis shrimp, etc.). It resembles a toothed beam-trawl and is made of an iron frame provided with 3-5 skids and a toothed bar on its lower side. These gears are usually towed at a greater speed (up to 10-13 km h-1) in comparison to the otter trawl nets; this is the reason of the name “rapido”, the Italian word for “fast”. The mesh opening of the codend used by the Italian rapido trawlers is larger (48 mm stretched or more) than the legal one. The main Italian rapido trawl fleets of GSA 17 are sited in the following harbours: Ancona, Rimini and Chioggia.

The Italian artisanal fleet in GSA 17, according to SoleMon project data (end of 2006), accounted for 469 vessels widespread in many harbours along the coast. They use gill nets or trammel nets especially from spring to fall and target small and medium sized sole (usually smaller than 25 cm TL).

5.2.5.1.2 Management regulations applicable in 2015

Italy and Slovenia :

- In Italy and Slovenia the main rules in force are based on the applicable EU regulations (mainly EC regulation 1967/206):
- Minimum landing sizes: 20 cm TL for sole.

- Cod end mesh size of trawl nets: 40 mm (stretched, diamond meshes) till 30/05/2010. From 1/6/2010 the existing nets have been replaced with a cod end with 40 mm (stretched) square meshes or a cod end with 50 mm (stretched) diamond meshes.
- Towed gears are not allowed within three nautical miles from the coast or at depths less than 50 m when this depth is reached at a distance less than 3 miles from the coast.
- Set net minimum mesh size: 16 mm stretched.
- Set net maximum length x vessel x day: 5,000 m

Croatia:

- Since the accession of Croatia to the EU the 1st if July 2013, the same regulations of Italy and Slovenia are implemented. Furthermore the following regulation are applied:
  - Beam trawl ("rapido"), according to the Fishing acts (Narodne novine, 148/2010, 25/2011), is gear for catching only shellfish, and the rate of other species in the catches cannot exceed 20%. Allowed mesh size for "rapido" is 40 mm (from knots to knots), and it is allowed to use only two rapido per vessel. Each rapido can be wide up to 4 meters.
  - The species is mainly caught with trammel nets, and minimum mesh size for trammel nets is 40 mm (inner nets) and 150 mm (outer nets). Maximum length of the nets allowed on the vessel is 6,000 m. If only one fisherman present on the vessel, the maximum allowed length is 4,000 m; for each additional fisherman an extra 1,000 m of net is allowed, up to 6000 m of total length per vessel. Maximum height of the nets is 4 m. Trammel nets can only be used only in the period from 10 September to 15 January.

5.2.5.1.3 Landings

Common sole landings estimated in the framework of 2015 Official Data Collection submitted in response to the 2014 data call are shown in Figure 5.2.5.4.3.1 and table 5.2.5.4.3.1, while Figure 5.2.5.4.3.2 and table 5.2.5.4.3.2 show the relative contributions of the different gears used by the Italian fleet and the landing by gear and country used in the assessment.

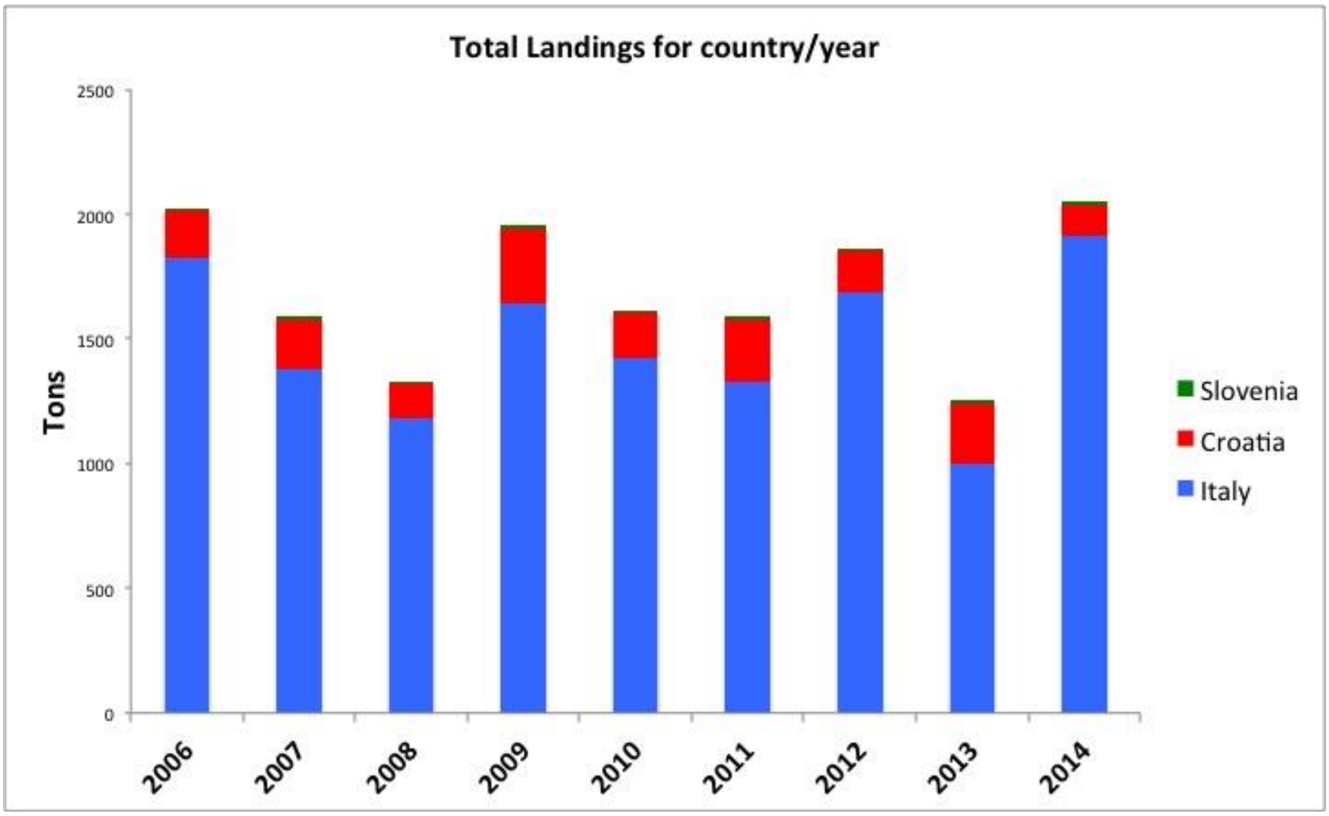


Figure 5.2.5.4.3.1. Common sole in GSA 17. Landings (all gears) in the GSA 17, from 2006 to 2014.

The eastern part of the basin contributes for about the 10% of the total landings, with on average 8 tons from Slovenia and 200 tons from Croatia.

Table 5.2.5.4.3.1. Common sole in GSA 17. Total landings (in tonnes) from 2006 to 2014.

YEAR	TOTAL LANDINGS
2006	2022
2007	1588
2008	1325
2009	1954
2010	1614
2011	1589
2012	1859
2013	1253
2014	2048

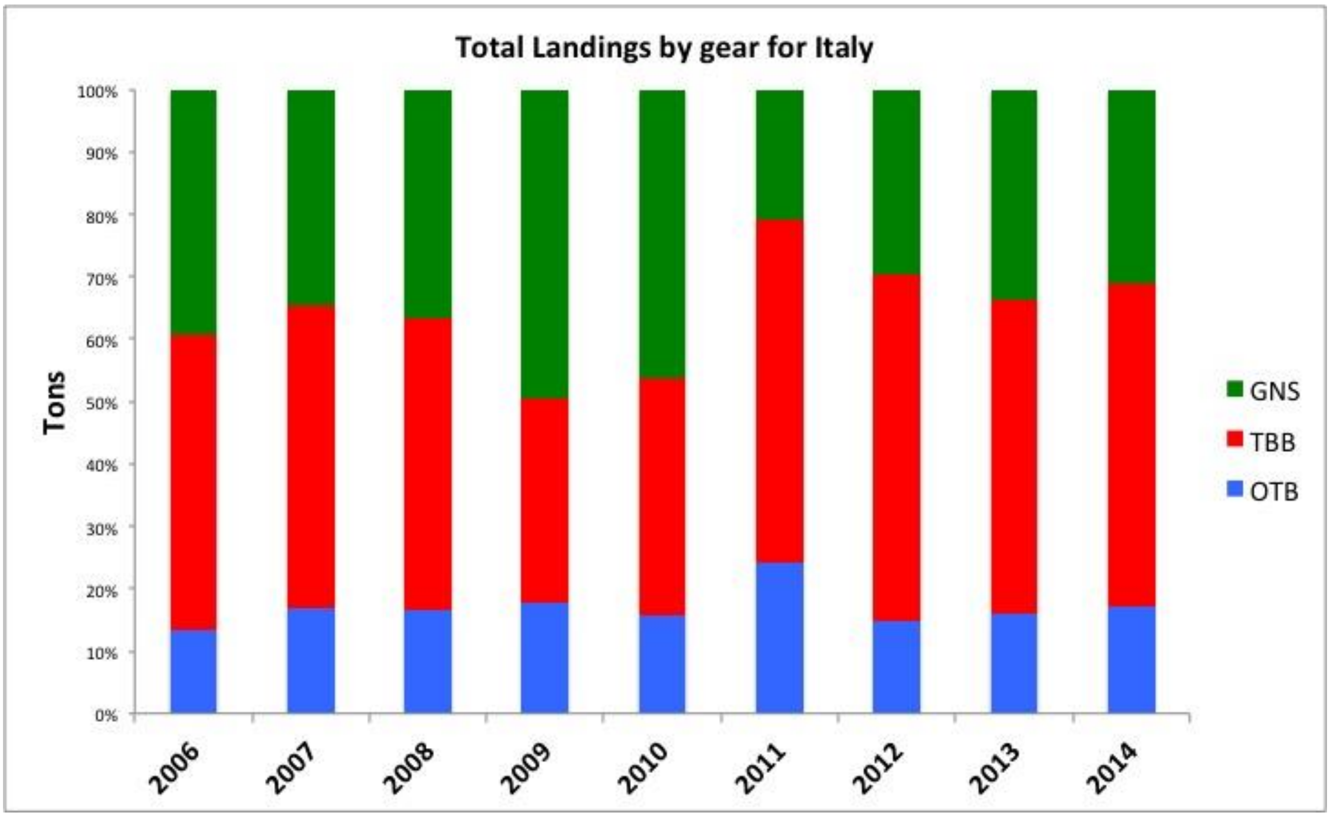


Figure 5.2.5.4.3.2. Common sole in GSA 17. Percentage of Italian landings (by gears) in the GSA 17, from 2006 to 2012.

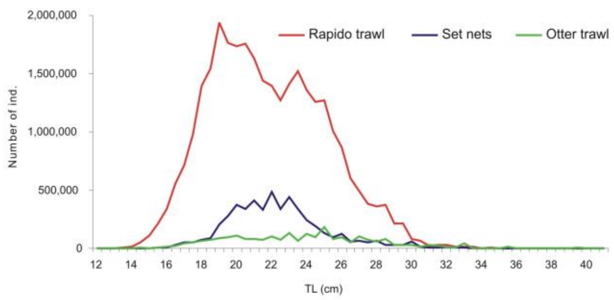
Table 5.2.5.4.3.2. Common sole in GSA 17. Landings by fishing fleet and gear from 1970 to 2014 from differect sources.

Total landings/year				
	total landings			
year	**GNS_Italy**	**TBB+OTB_Italy**	**GTR_Croatia+Slovenia**	**Total GSA17**
1970	580	1031	258	1869
1971	489	869	217	1575
1972	534	948	237	1719
1973	549	976	244	1769
1974	607	1080	270	1957
1975	567	1007	252	1826
1976	694	1235	309	2238
1977	788	1400	350	2538
1978	672	1194	299	2165
1979	897	1594	399	2890
1980	694	1233	308	2235
1981	348	620	155	1123
1982	377	669	167	1213
1983	513	911	228	1652
1984	440	781	195	1416

1985	480	854	213	1547
1986	494	878	220	1592
1987	823	1464	366	2653
1988	619	1101	275	1995
1989	586	1043	261	1890
1990	383	682	170	1235
1991	365	650	162	1177
1992	590	1048	262	1900
1993	625	1110	278	2013
1994	711	1265	316	2292
1995	612	1087	272	1971
1996	379	673	168	1220
1997	388	690	172	1250
1998	367	653	163	1183
1999	397	705	176	1278
2000	309	559	168	1036
2001	319	579	206	1104
2002	298	539	238	1075
2003	633	1147	327	2107
2004	561	1015	246	1822
2005	594	1075	325	1994
2006	717	1106	199	2022
2007	466	913	209	1588
2008	410	775	140	1325
2009	509	1134	311	1954
2010	520	901	193	1614
2011	625	706	258	1589
2012	781	906	172	1859
2013	207	793	253	1253
2014	562	1350	136	2048

DCF
FAO Fishstat
Combined DCF (for SVN)/FAO Fishstat-Primo Project (for HRV)

Rapido trawl landings were traditionally dominated by small sized specimens; they are basically composed by 1 and 2 year old individuals. Set net fishery lands mostly the same portion of the population, while the otter trawl fishery, exploiting wider fishing grounds, shows a different size distribution of the landings (Figure 5.2.5.4.3.3). In the eastern part of the basin common sole is exploited mainly by set netters (using trammel net), and the catch composition, as suggested by preliminary data collection carried out in 2010 by Croatian colleagues in the framework of Primo Project, is dominated by adult (Figure 5.2.5.4.3.3).
In Figures 5.2.5.4.3.4-6, the length frequency DCF data from the Italian landings are shown for OTB, GNS and TBB. Conversely, Figures 5.2.5.4.3.7-9 and table 5.2.5.5.3.3 show the age frequency DCF data from the Italian landings are shown for OTB, GNS and TBB.



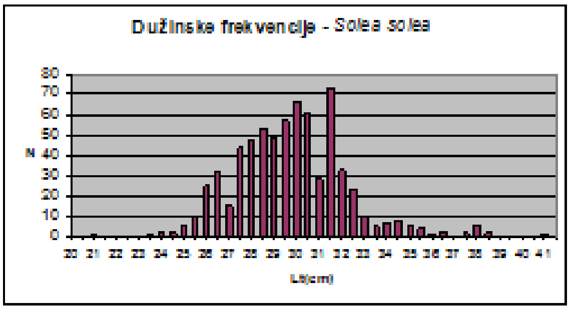


Figure 5.2.5.4.3.3. Common sole in GSA 17. Size structure of the landings provided in 2005-2006 by *rapido* trawl, otter trawl and set nets in the GSA 17 (SoleMon project data; left). Size structure of the landings in 2010 by set nets in the eastern part of GSA 17.

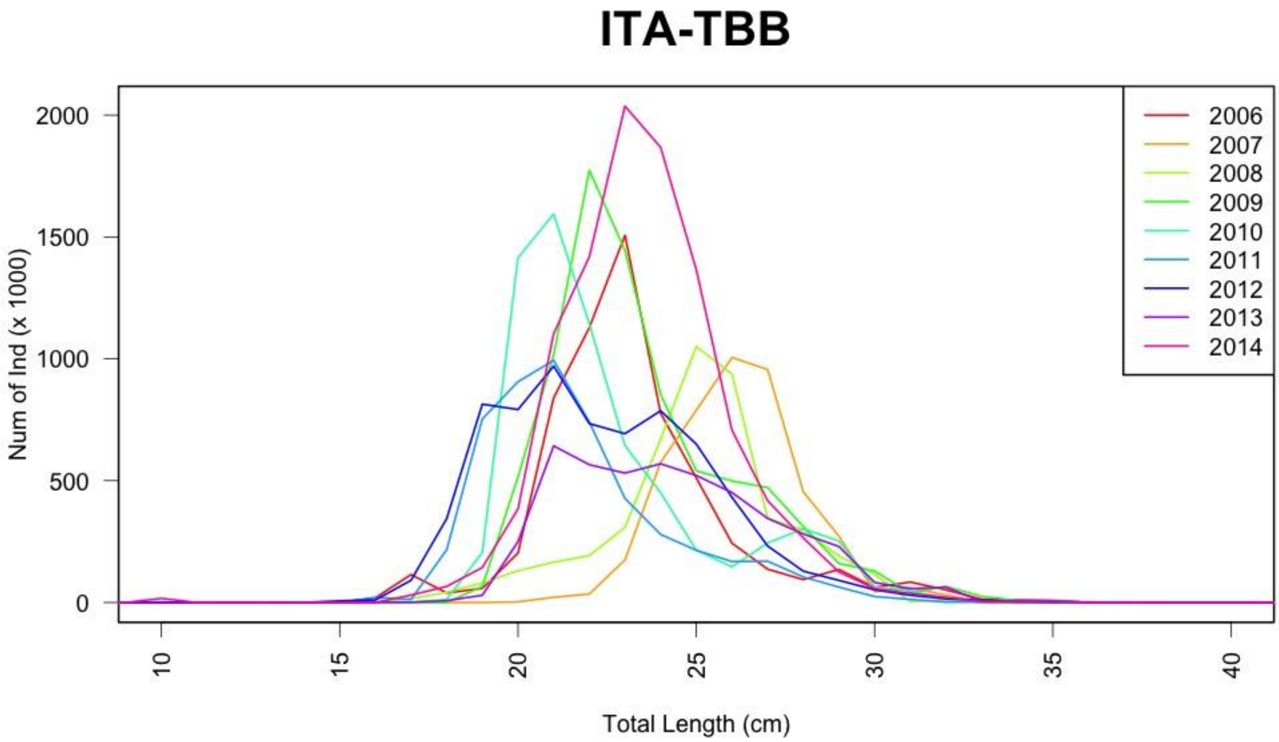


Figure 5.2.5.4.3.4. Common sole in GSA 17. Size structure of the landings in 2006-2014 provided by the 2014 Italian DCF data call for GSA 17- TBB.

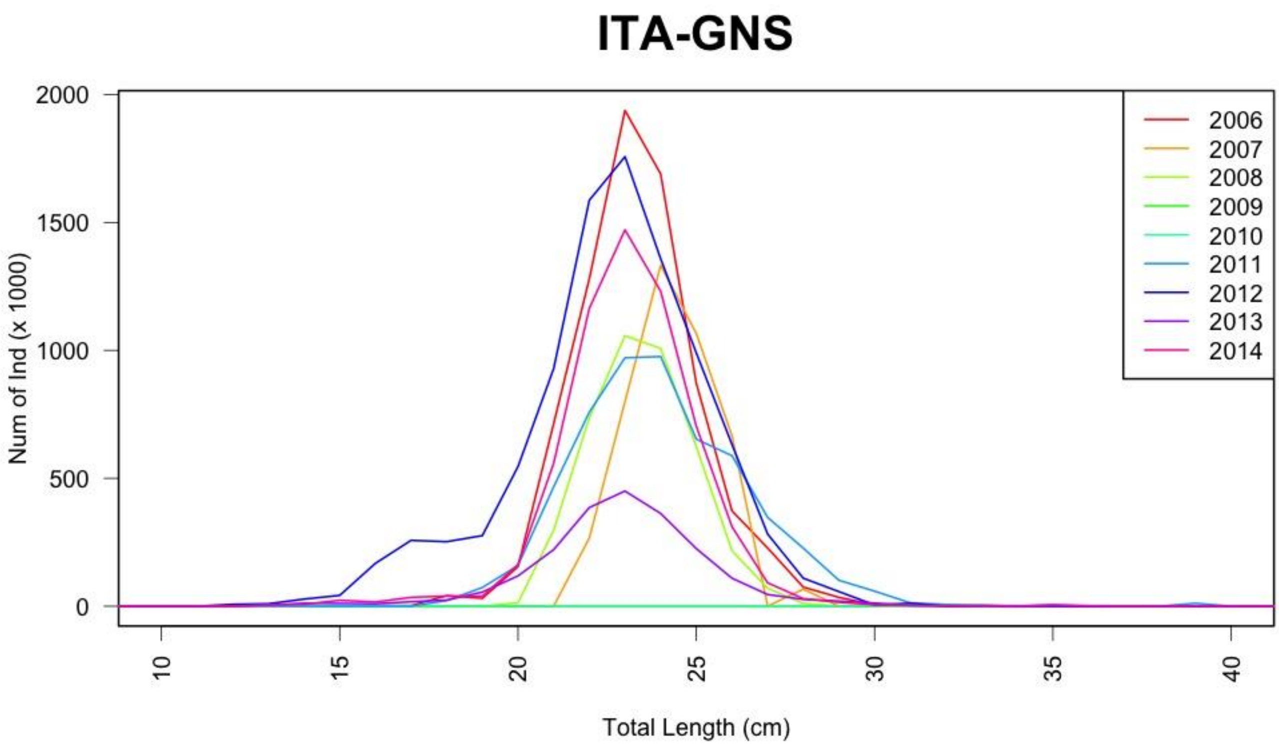


Figure 5.2.5.4.3.5. Common sole in GSA 17. Size structure of the landings in 2006-2014 provided by the 2014 Italian DCF data call for GSA 17; GNS.

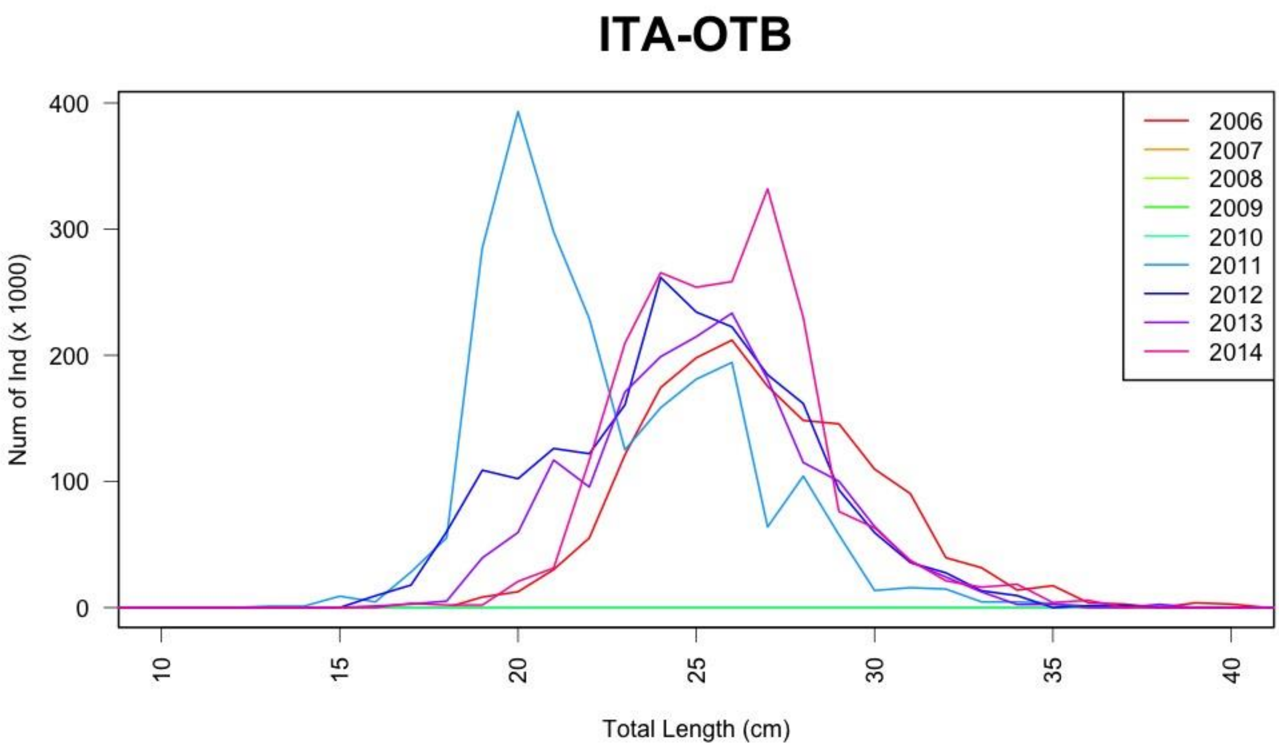


Figure 5.2.5.4.3.6. Common sole in GSA 17. Size structure of the landings in 2006-2014 provided by the 2014 Italian DCF data call for GSA 17; OTB.

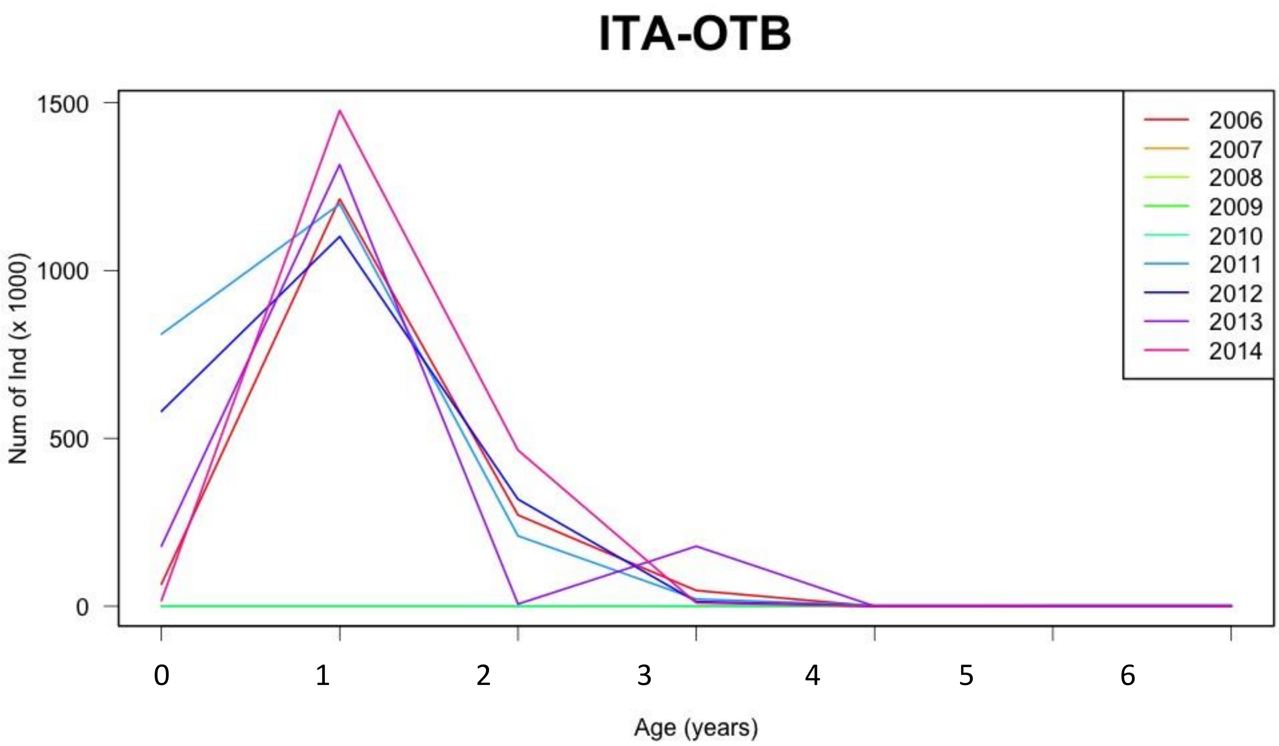


Figure 5.2.5.4.3.7. Common sole in GSA 17. Age structure of the landings in 2006-2014 provided by the 2014 Italian DCF data call for GSA 17; OTB.

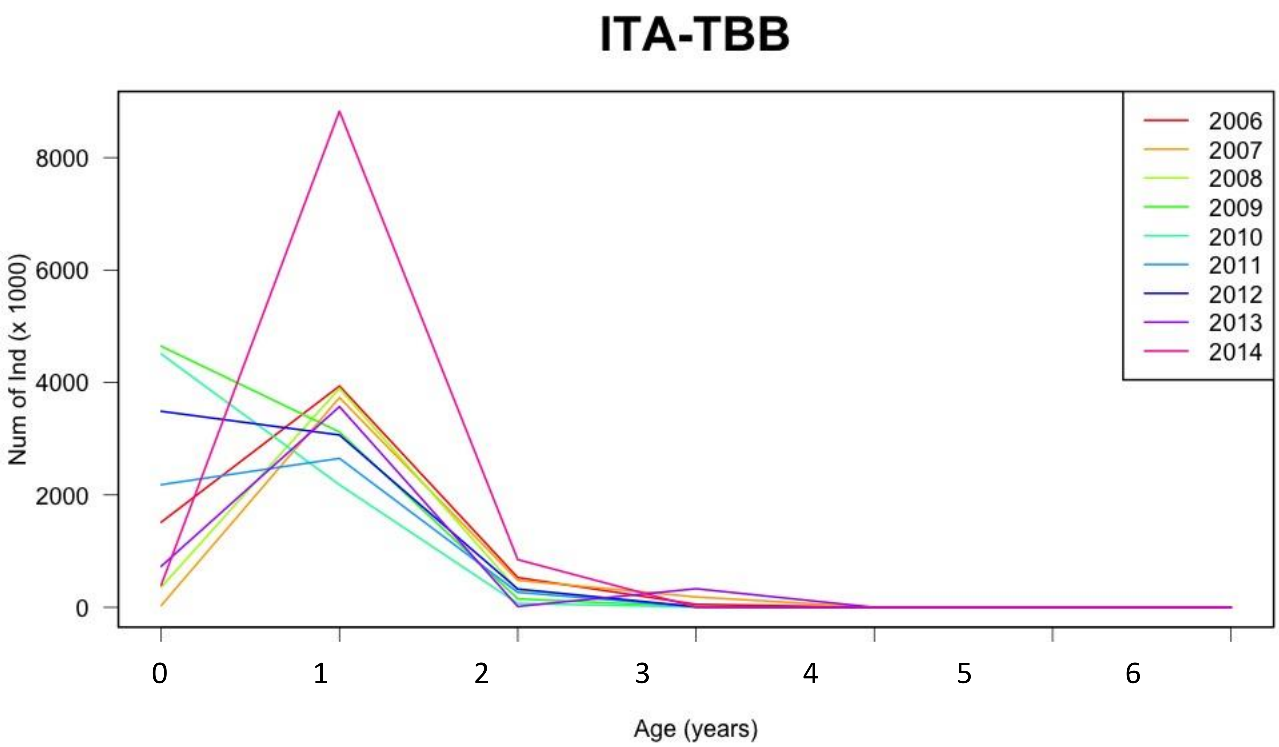


Figure 5.2.5.4.3.8. Common sole in GSA 17. Age structure of the landings in 2006-2014 provided by the 2014 Italian DCF data call for GSA 17; TBB.

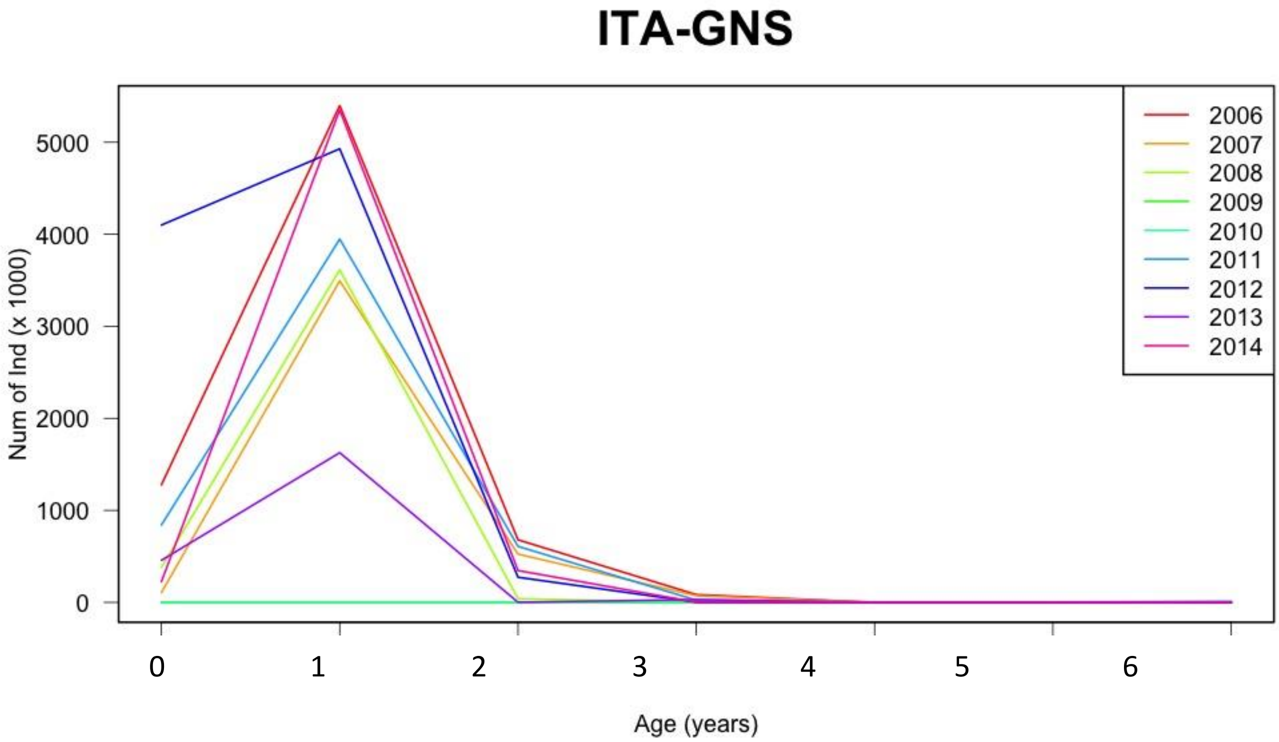


Figure 5.2.5.4.3.9. Common sole in GSA 17. Age structure of the landings in 2006-2014 provided by the 2014 Italian DCF data call for GSA 17- GNS.

Table 5.2.5.4.3.3. Common sole in GSA 17. Age structure of the landings in 2006-2014 provided by the 2014 DCF data call for GSA 17 by gear and country.

	GTR_Croatia+Slovenia						
Year	Age0	Age1	Age2	Age3	Age4	Age5	Age6
2006	0.00	0.00	134.00	518.00	27.00	5.00	3.00
2007	0.00	0.00	155.00	601.00	31.00	6.00	3.00
2008	0.00	0.00	96.00	373.00	19.00	3.00	2.00
2009	0.00	0.00	244.00	948.00	49.00	9.00	5.00
2010	0.00	0.00	140.00	544.00	28.00	5.00	3.00
2011	0.00	0.00	173.00	671.00	35.00	6.00	4.00
2012	0.00	0.00	116.00	449.00	23.00	4.00	2.00
2013	0.00	0.00	162.23	629.18	32.46	5.77	3.36
2014	0.00	0.00	135.74	526.46	27.16	4.83	2.81
	TBB+OTB_Italy						
2006	1937.09	6214.83	958.45	118.64	0.00	0.00	0.00
2007	339.97	5528.16	801.88	287.53	0.53	0.59	0.59
2008	571.56	4603.01	473.79	63.02	0.47	0.53	0.53
2009	5112.24	4532.17	406.93	49.06	0.68	0.76	0.76
2010	4442.53	2984.88	248.39	37.42	0.56	0.63	0.63
2011	4358.41	3435.84	413.99	26.52	3.75	3.16	3.16
2012	4053.18	4151.68	641.82	23.69	0.00	0.00	0.00

2013	960.71	4935.30	22.03	513.02	0.00	0.00	0.00
2014	420.65	10462.18	1324.30	14.89	0.00	0.00	0.00
	GNS_Italy						
2006	1016.70	4293.54	540.95	66.92	0.00	0.00	0.00
2007	89.78	2942.57	442.14	60.43	0.00	0.00	0.00
2008	298.27	2835.09	31.72	0.00	0.00	0.00	0.00
2009	854.80	3239.08	276.19	32.95	0.29	0.44	1.53
2010	873.27	3213.16	265.86	14.80	0.30	0.45	1.57
2011	815.00	3830.45	601.80	23.81	2.11	3.17	11.01
2012	4081.12	4905.82	272.14	2.35	0.00	0.00	0.00
2013	454.49	1617.66	1.40	30.62	0.00	0.00	0.00
2014	225.05	5335.65	345.43	2.31	0.00	0.00	0.00

5.2.5.1.4 Discards

Several projects carried out in a portion of GSA 17 highlighted that discards of sole both by rapido trawl and set net fisheries is negligible (Fabi et al., 2002a; 2002b) since the damaged specimens are also commercialized, even though at a lower price.

The available discard data for the Italian DCF are shown in figures 5.2.5.4.4.1-3 and tables 5.2.5.4.4.1-2 for the total and the different gears.

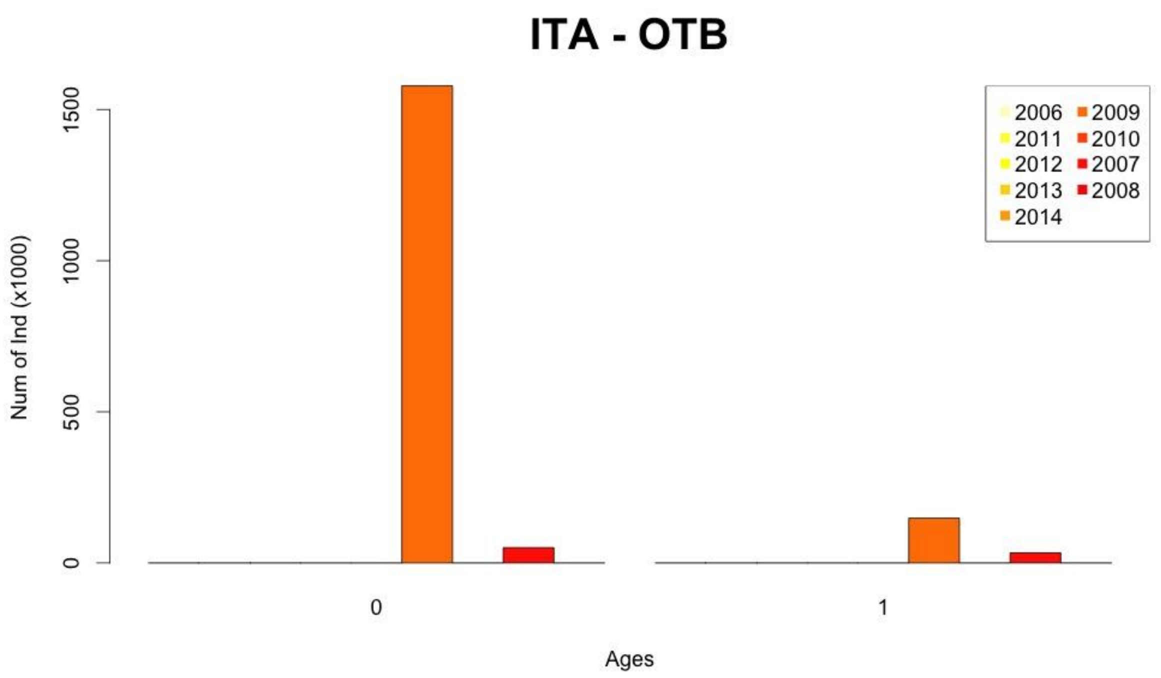


Figure 5.2.5.4.4.1. Common sole in GSA 17. Discard data by age for the Italian fleet; OTB.

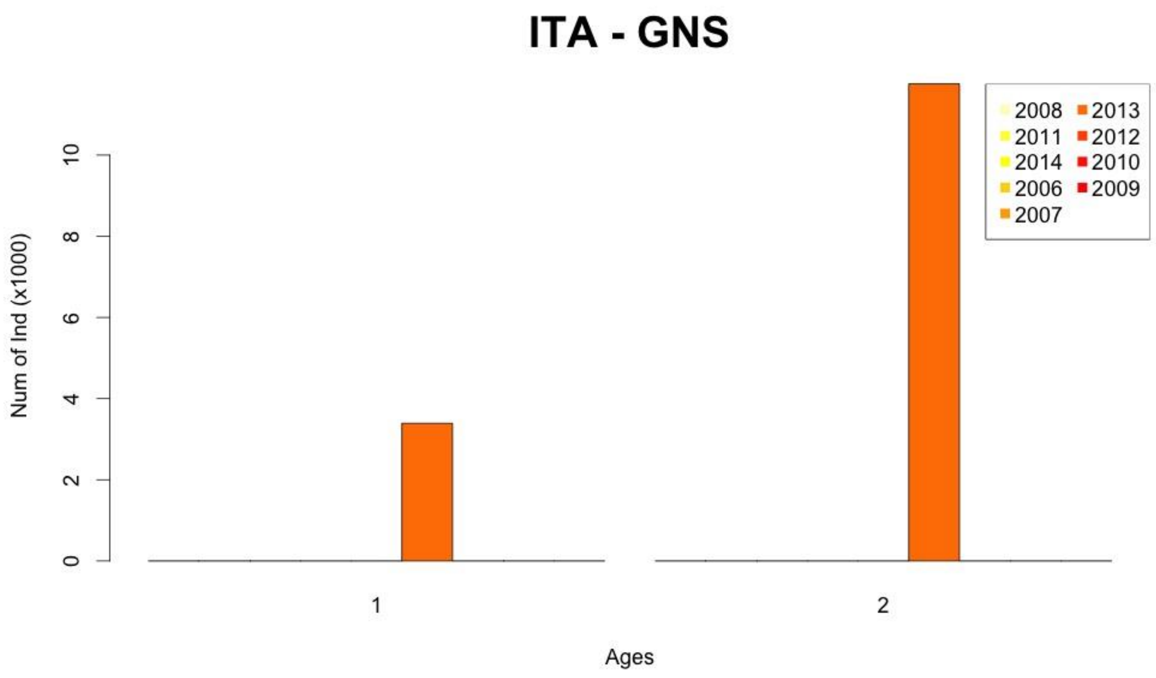


Figure 5.2.5.4.4.2. Common sole in GSA 17. Discard data by age for the Italian fleet; GNS.

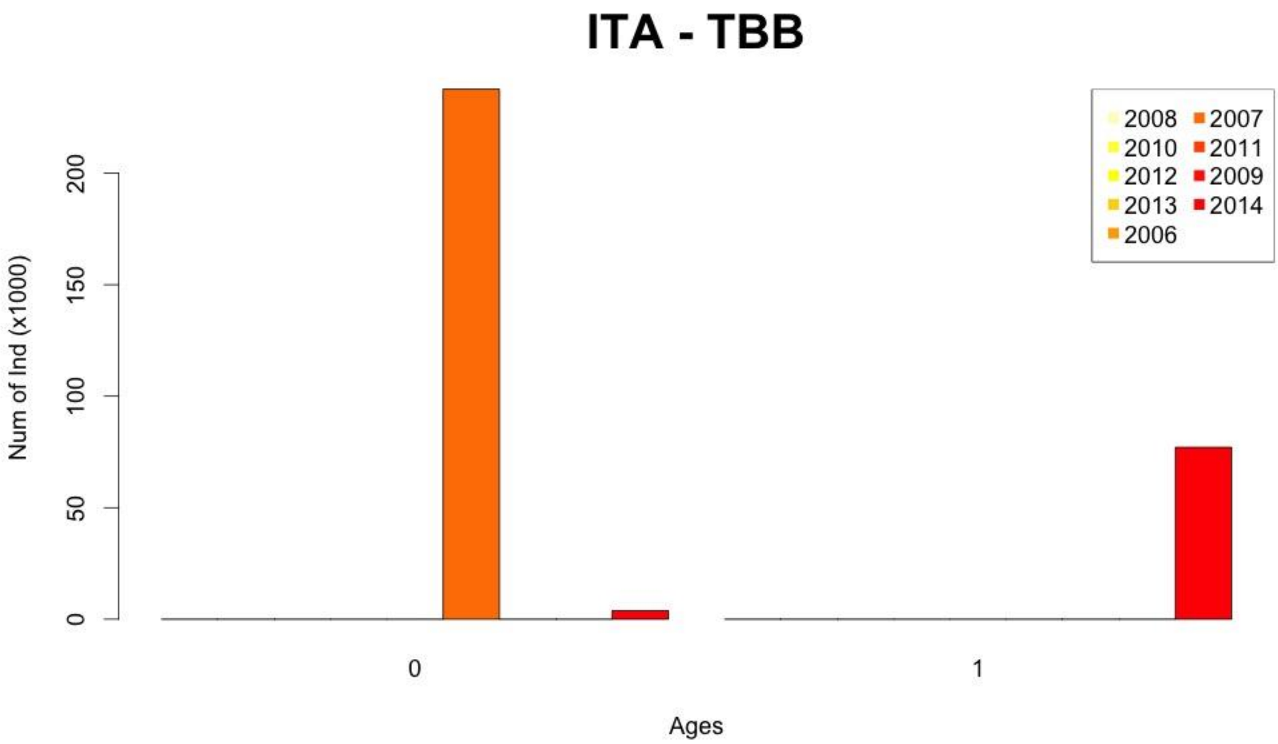


Figure 5.2.5.4.4.3. Common sole in GSA 17. Discard data by age for the Italian fleet; TBB.

Table 5.2.5.4.4.1. Common sole in GSA 17. Total tonnes of discard for Italy from 2006 to 2014.

year	Total GSA17

2006	0.008
2007	0.018
2008	0.012
2009	0.03
2010	0.026
2011	0.018
2012	0.01
2013	0.067
2014	0.048

Table 5.2.5.4.4.2. Common sole in GSA 17. Total tonnes of discard for Italy from 2006 to 2014 by gear.

	total landings		
year	**GNS - Italy**	**GTR - Italy**	**OTB - Italy**
2006	0.003	0.005	0
2007	0.017	0.001	0
2008	0.01	0.002	0
2009	0.004	0.026	0
2010	0.014	0.012	0
2011	0.004	0.014	0
2012	0.008	0.002	0
2013	0.04	0.027	0
2014	0.024	0.023	0.001

5.2.5.1.5 Fishing effort

Effort data from the 2014 DCF data call are listed in the tables below respectively for Italy, Slovenia and Croatia (Tables 5.2.5.4.5.1-2) and shown in Figures 5.2.5.4.5.1-3. It is possible to observe a remarkable decrease of the OTB effort in Italy, while the other gears show a generally constant trend in fishing effort. Conversely, Slovenian effort data shows a clear increasing trend for all the gear categories.

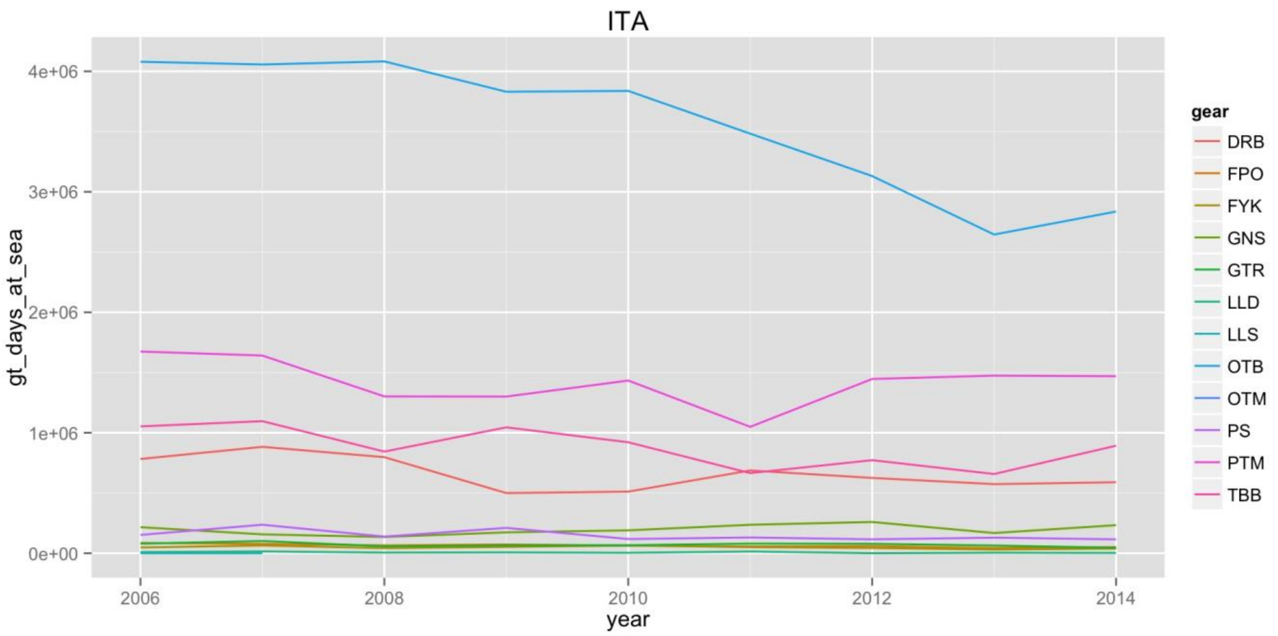


Figure 5.2.5.4.5.1. Common sole in GSA 17. Effort data (gt_days_at_sea) for the Italian fleet, by gear, in the period 2006-2014.

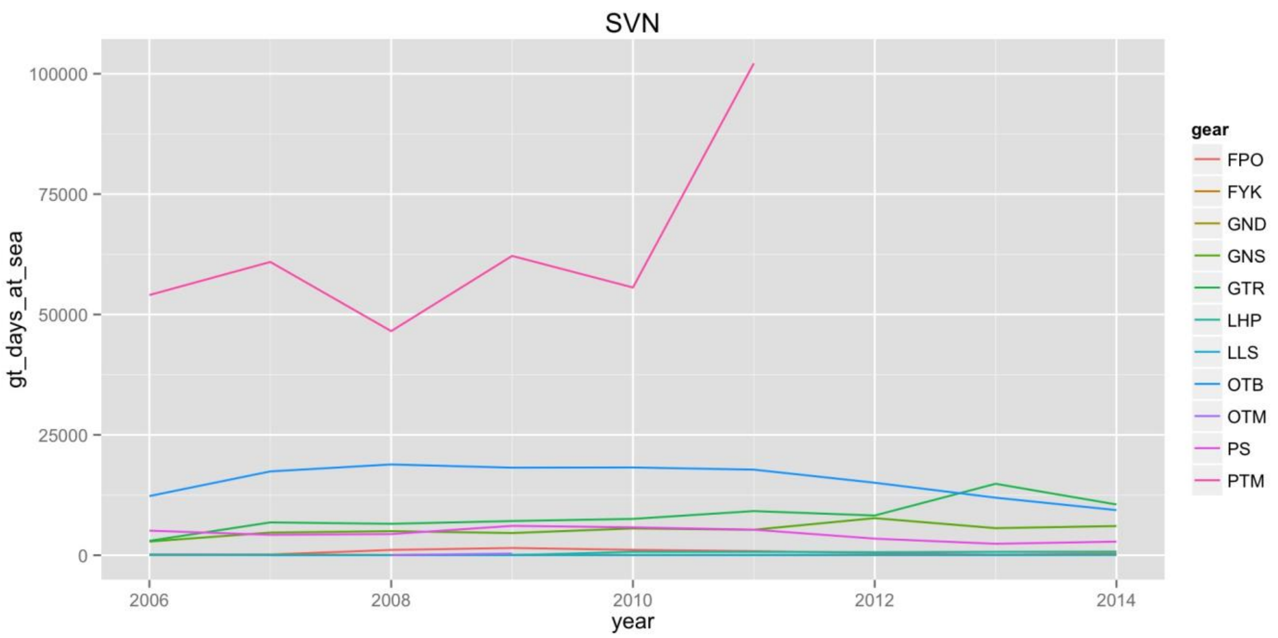


Figure 5.2.5.4.5.2. Common sole in GSA 17. Effort data (gt_days_at_sea) for the Slovenian fleet, by gear, in the period 2006-2014.

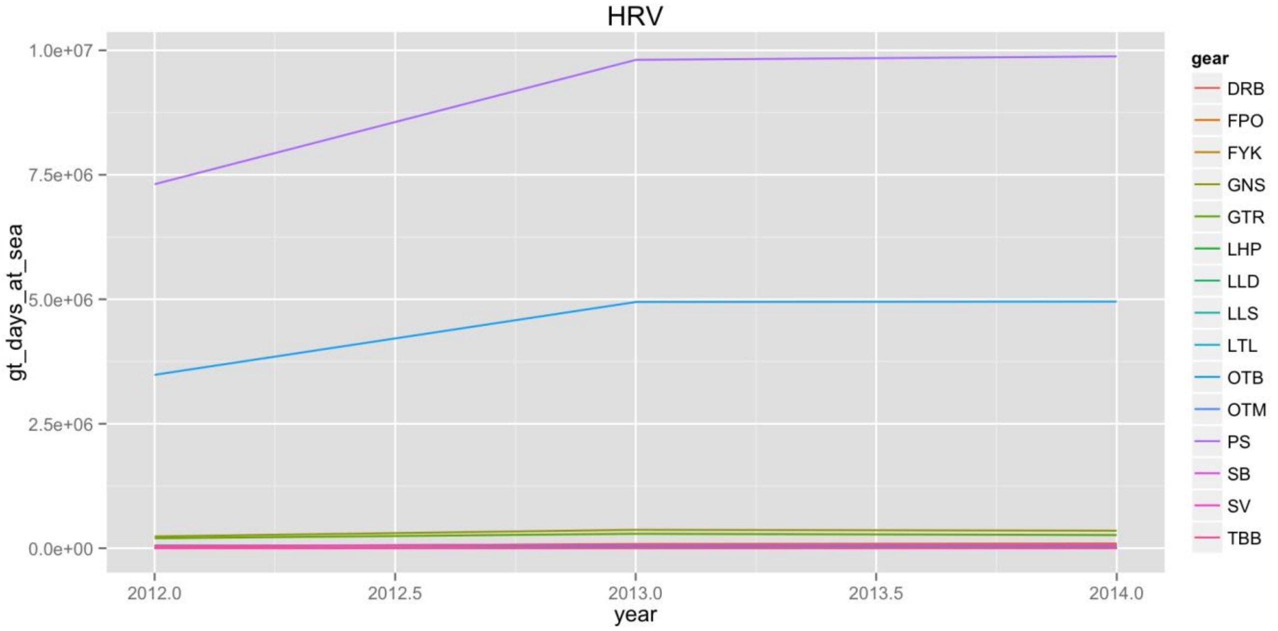


Figure 5.2.5.4.5.3. Common sole in GSA 17. Effort data (gt_days_at_sea) for the Croatian fleet, by gear, in the period 2006-2014.

Table 5.2.5.5.6.1. Common sole in GSA 17. Fishing effort in GT days at sea by fleet for the main gears targeting *S. solea* in GSA 17 for the period 2004-2014**.**

GT days at sea						
	ITA			SLO		HRV
Year	ITA - GNS	ITA - OTB	ITA - TBB	SLO - OTB	SLO - other	GNS
2004	245185	3543021	1003129	-	0	
2005	262674	4205417	785589	9155	74113	
2006	215431	3759299	1052912	12291	65429	
2007	156782	3779272	1096364	17413	77090	
2008	134853	4031883	843741	18858	63715	
2009	172839	3804025	1045203	18191	82011	
2010	190127	3795874	921158	18235	75770	
2011	236241	3447262	665155	17782	122922	
2012	258525	3060578	772706	15063	20003	237824.59
2013	167797	2642061	657556	11960	23063	370417.67
2014	233376	2711270	892595	9372	20244	352949.48

Table 5.2.5.5.6.2. Common sole in GSA 17. Nominal fishing effort in Kw days at sea by fleet for the main gears targeting *S. solea* in GSA 17 for the period 2004-2014.

Nominal Effort [Kw days at sea]						
	ITA			SLO		HRV
Year	ITA - GNS	ITA - OTB	ITA - TBB	SLO - OTB	SLO - other	GTR
2004	4474535	21087676	4232537		0	
2005	4980544	20335938	3812915	112663	389120	
2006	4304857	18657299	4946237	143526	357976	

2007	2538855	18308149	5231834	183978	463909	
2008	2446686	19842127	4136346	198181	441511	
2009	3270215	18788561	4386154	200880	530306	
2010	3394794	17935158	3817491	207862	517082	
2011	4642260	16434634	2584717	188621	724230	
2012	5280623	13751962	3254187	153646	356149	3737005.59
2013	2974353	12597554	2769675	113694	388581	5734066.36
2014	3864370	14117196	3729815	99847	351421	5549831.14

Conversely Figures 5.2.5.4.5.4-7 show the trends for the LPUE for the whole Italian fleet and for the single gears.

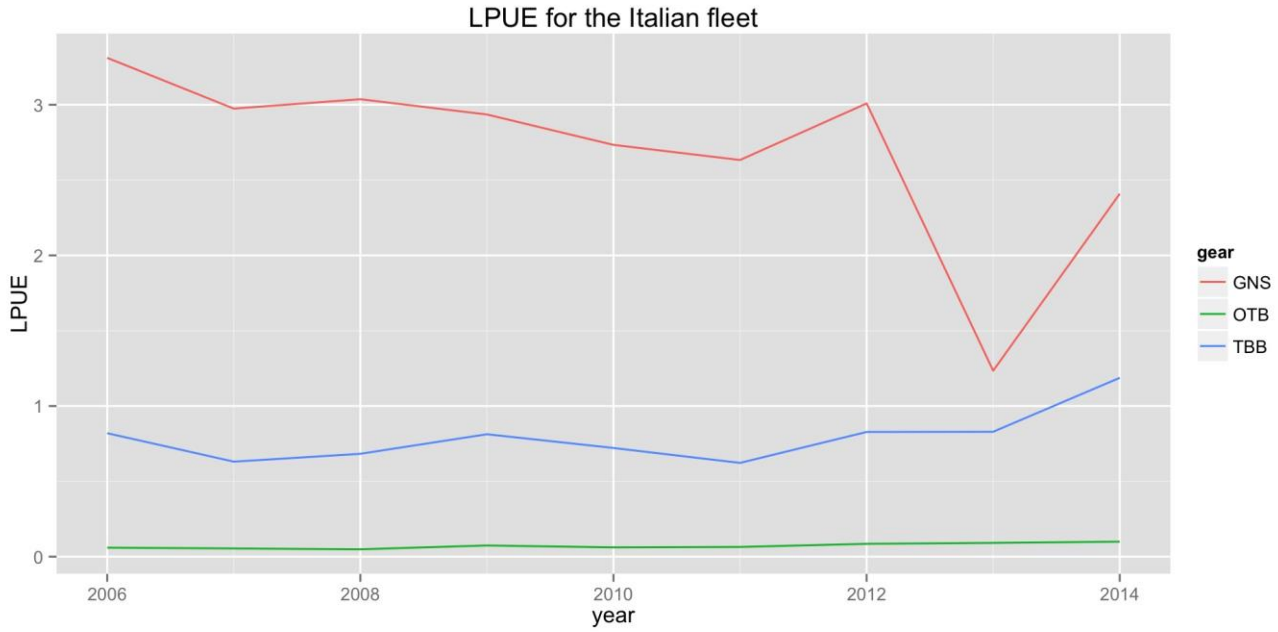


Figure 5.2.5.4.5.4. Common sole in GSA 17. LPUE data for the whole Italian fleet in the period 2006-2014.

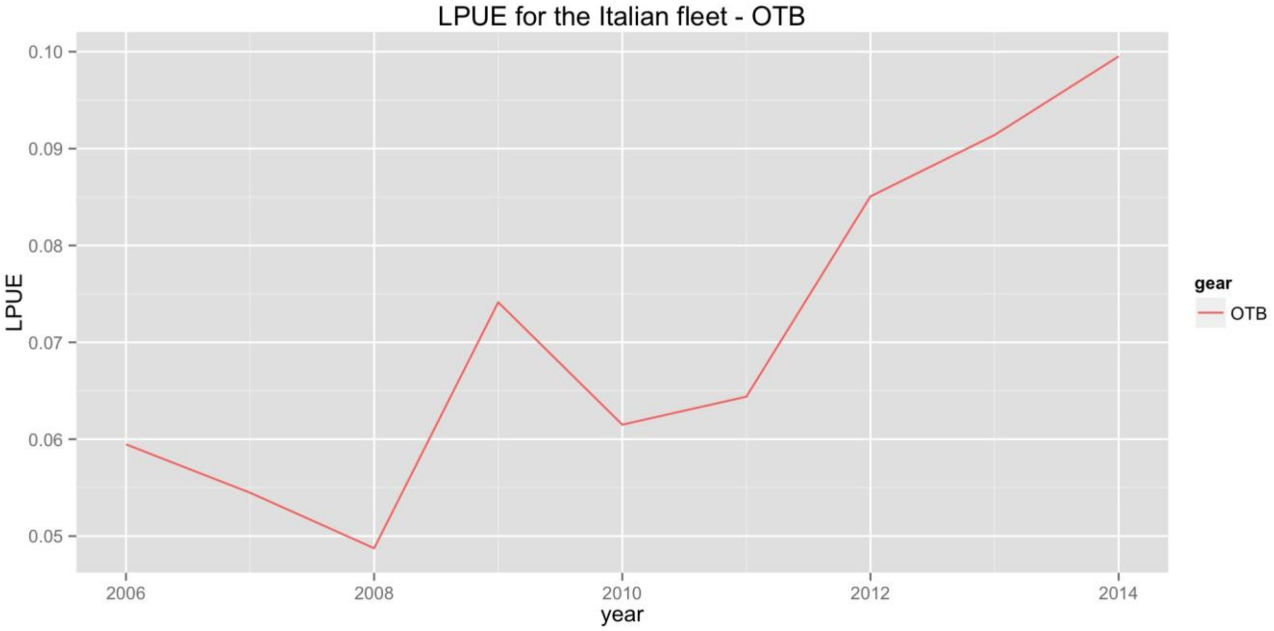


Figure 5.2.5.4.5.5. Common sole in GSA 17. LPUE data for the OTB Italian fleet in the period 2006-2014.

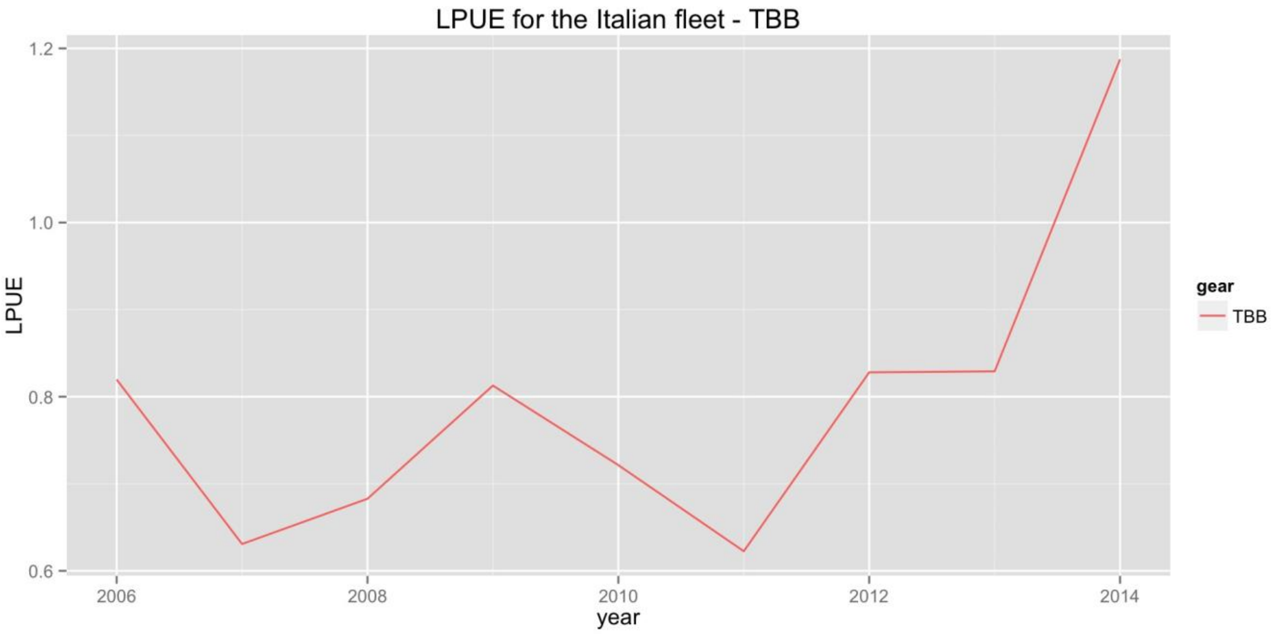


Figure 5.2.5.4.5.6. Common sole in GSA 17. LPUE data for the TBB Italian fleet in the period 2006-2014.

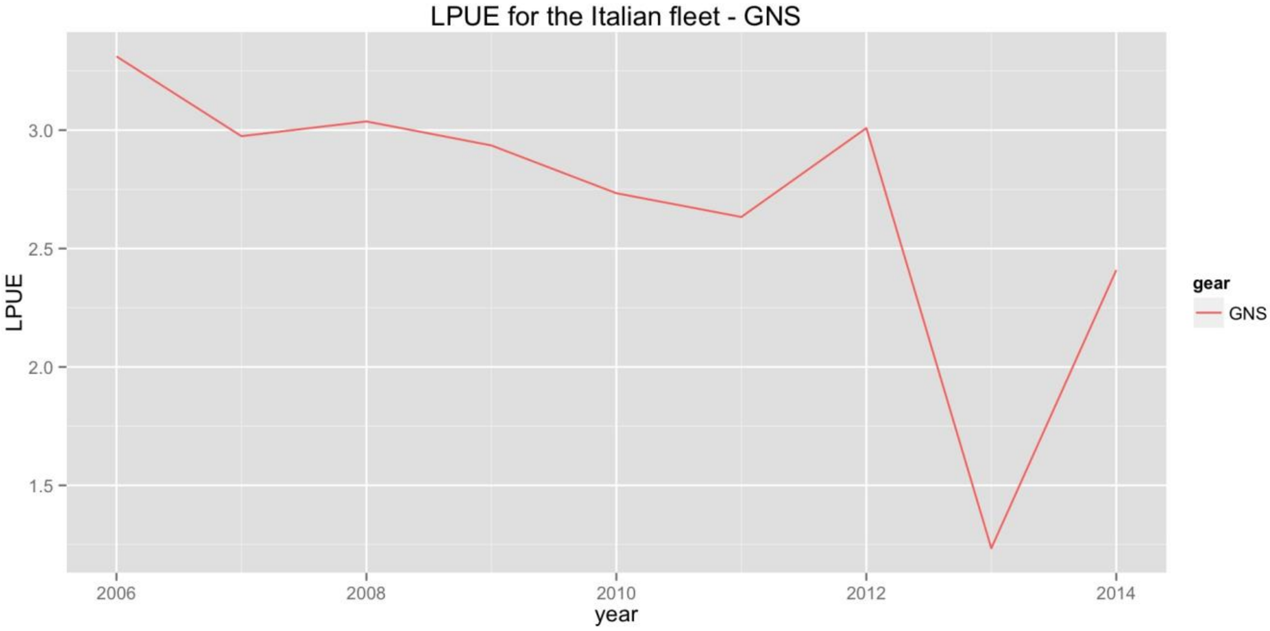


Figure 5.2.5.4.5.7. Common sole in GSA 17. LPUE data for the GNS Italian fleet in the period 2006-2014.

Figure 5.2.5.4.5.8 shows the fall rapido-trawl effort of Italian vessels over the years 2006–2011 in GSA 17. The first zone of effort concentration is inshore between 3 and 9 nautical miles from the Italian coast, between 43° and 44° latitude, and is mainly exploited by vessels belonging to Ancona and Rimini Harbours. The second zone is between Po river mouth and Venice lagoon and is concentrated at the same distance from the coast as the first region. This region is mainly exploited by the Chioggia rapido trawl fleet. The third area of effort concentration is offshore, near Istria peninsula and is exploited by both Chioggia and Rimini rapido trawl fleets. As expected, the area is characterised by a low abundance of sole, as suggested by survey data in Grati et al. (2013), and has a relatively low fishing effort. The area southward of this last region is not exploited by rapido trawlers mainly due to the high concentrations of debris and benthic communities that are dominated by holothurians (Despalatović et al., 2009). The data presented in the Figure 5.2.5.4.5.8 are quite important in order to explain the population selectivity curves used in the SS3 model in order to carry out the Statistical Catch at Age analysis (see discussion below).

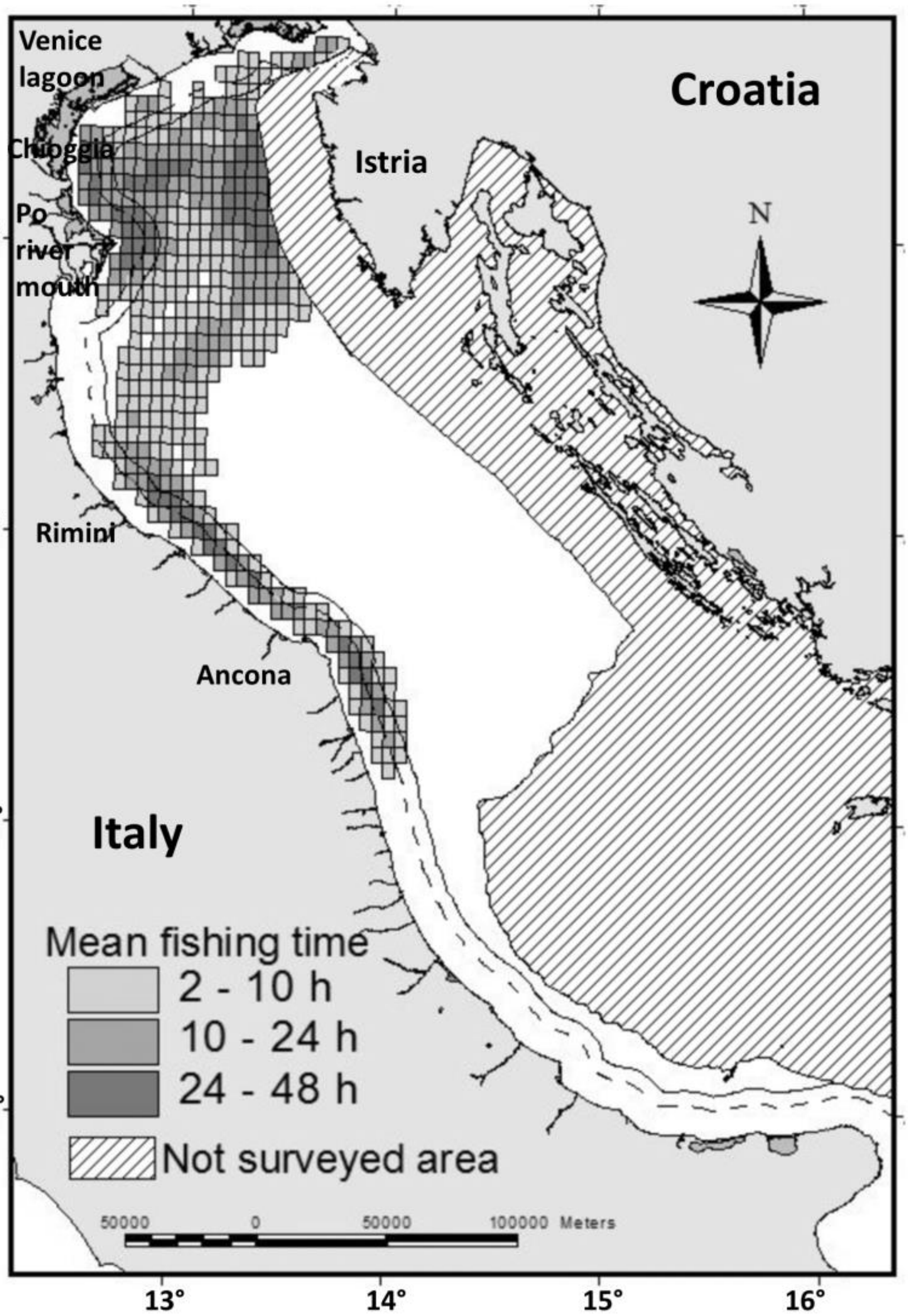


Figure 5.2.5.4.5.8. Common sole in GSA 17. Maps of spatial distribution of rapido trawl fishing effort estimated in mean fishing hours in each 5 x 5 km rectangle. The 6 and 9 nautical miles from the Italian coast are shown respectively by broken and continuous black lines (Scarcella et al., 2014).

Scientific surveys: SOLEMON

With reference to the SoleMon project, twelve rapido trawl fishing surveys were carried out in GSA 17 from 2005 to 2014: two systematic "pre-surveys" (spring and fall 2005) and four random surveys (spring and fall 2006, fall 2007-2012) stratified on the basis of depth (0-30 m, 30-50 m, 50-100m). Hauls were carried out by day using 2-4 rapido trawls simultaneously (stretched codend mesh size = 40.2 ± 0.83). The following number of hauls was reported per depth stratum (Tab. 5.2.5.5.1).

Table 5.2.5.5.1. Common sole in GSA 17. Number of hauls per year and depth stratum in GSA 17, 2005-2012.

Depth strata	Spring 2005	Fall 2005	Spring 2006	Fall 2006	Fall 2007	Fall 2008-2012
0-30	30	30	20	35	32	39
30-50	14	12	10	20	19	17
50-100	24	15	8	8	11	11
HR islands	0	5	4	4	0	0
TOTAL	68	62	42	67	62	67

Abundance and biomass indexes from rapido trawl surveys were computed using ATrIS software (Gramolini et al., 2005) which also allowed drawing GIS maps of the spatial distribution of the stock, spawning females and juveniles.
The abundance and biomass indices by GSA 17 were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum area in the GSA 17:

$$Yst = \Sigma (Yi*Ai) / A$$

$$V(Yst) = \Sigma (Ai^2 * si^2 / ni) / A^2$$

Where:
A=total survey area
Ai=area of the i-th stratum
si=standard deviation of the i-th stratum
ni=number of valid hauls of the i-th stratum
n=number of hauls in the GSA
Yi=mean of the i-th stratum
Yst=stratified mean abundance
V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as standard deviation.
Length distributions represented an aggregation (sum) of all standardized length frequencies over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance and finally aggregated (sum) over the strata to the GSA. Given the sheer number of plots generated, these distributions are not presented in this report.

Geographical distribution patterns
According to data collected during SoleMon surveys (Scarcella et al., 2014), age class 0+ aggregates inshore along the Italian coast, mostly in the area close to the Po river mouth (Figure 5.2.5.5.1.1). Age class 1+ gradually migrates off-shore and adults concentrate in the deepest waters located at South West from Istria peninsula.

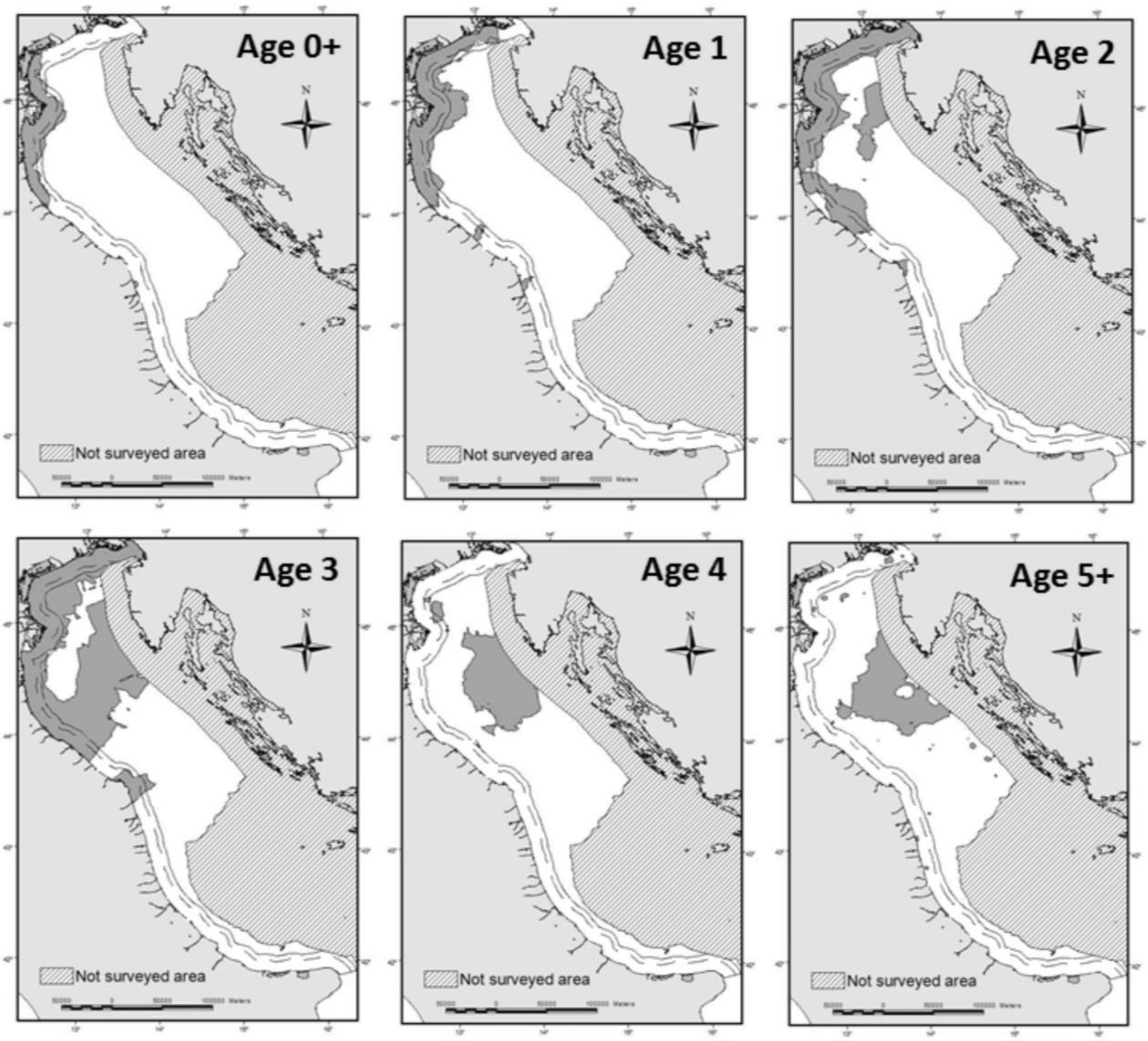


Figure 5.2.5.5.1.1. Common sole in GSA 17. Maps of hotspots calculated for the different age classes. The 6 and 9 nautical miles from the Italian coast are shown respectively by broken and continuous black lines (Scarcella et al., 2014).

Trends in abundance and biomass

The SoleMon trawl surveys provided data either on sole total abundance and biomass as well as on important biological events (recruitment, spawning). Figure 5.2.5.5.2.1 shows the abundance and biomass indices of sole obtained from 2005 to 2014; slightly increasing trends occurred till fall 2007, followed by a decrease in fall 2008-2009, and an increase in 2010-2014.

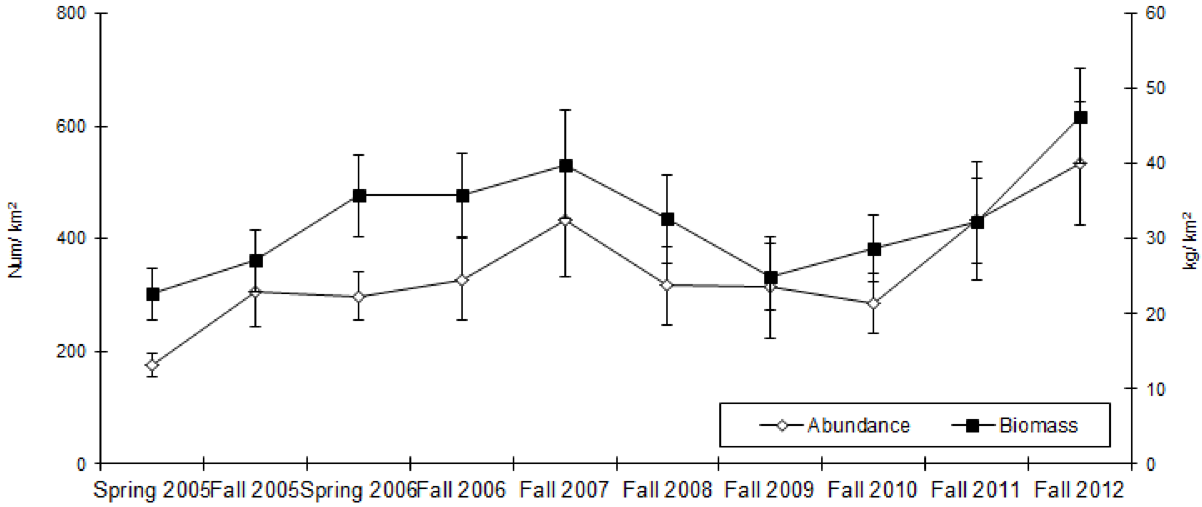


Figure 5.2.5.5.2.1. Common sole in GSA 17. Abundance and biomass indices obtained from the SoleMon survey.

Figure 5.2.5.5.2.2 shows the abundance and biomass indices of sole recruits (less than 20 cm) obtained from 2005 to 2014; wide oscillation were observed in the period 2005 – 2010 followed by a clear increase in the last years.

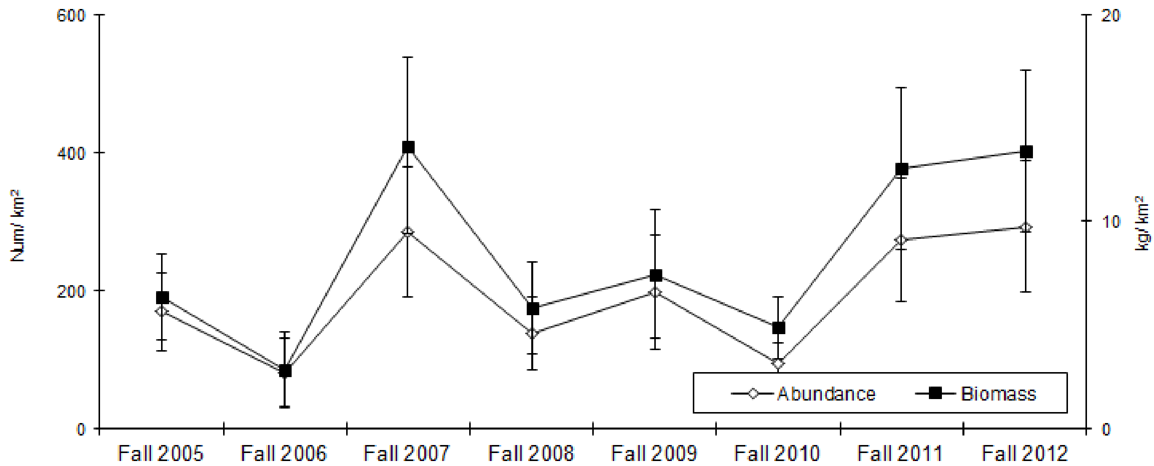


Figure 5.2.5.5.2.2. Common sole in GSA 17. Abundance and biomass indices of recruits obtained from SoleMon surveys.

Figure 5.2.5.5.2.3 shows the abundance and biomass indices of sole adults (more than 25.8 cm) obtained from 2005 to 2012; after a decreasing trend observed from 2007 to 2010 an increase has been observed in the last years.

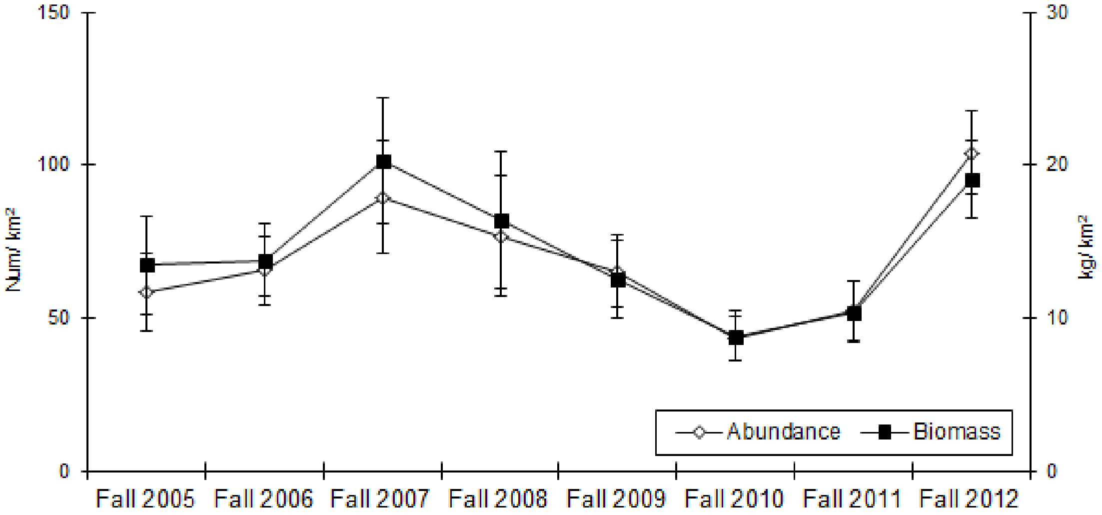


Figure 5.2.5.5.2.3. Common sole in GSA 17. Abundance and biomass indices of adults obtained from the SoleMon survey.

Trends in abundance by length or age

Figure 5.2.5.5.3.1 displays the stratified length frequency ditributions obtained in the GSA 17 in the years 2005-2014.

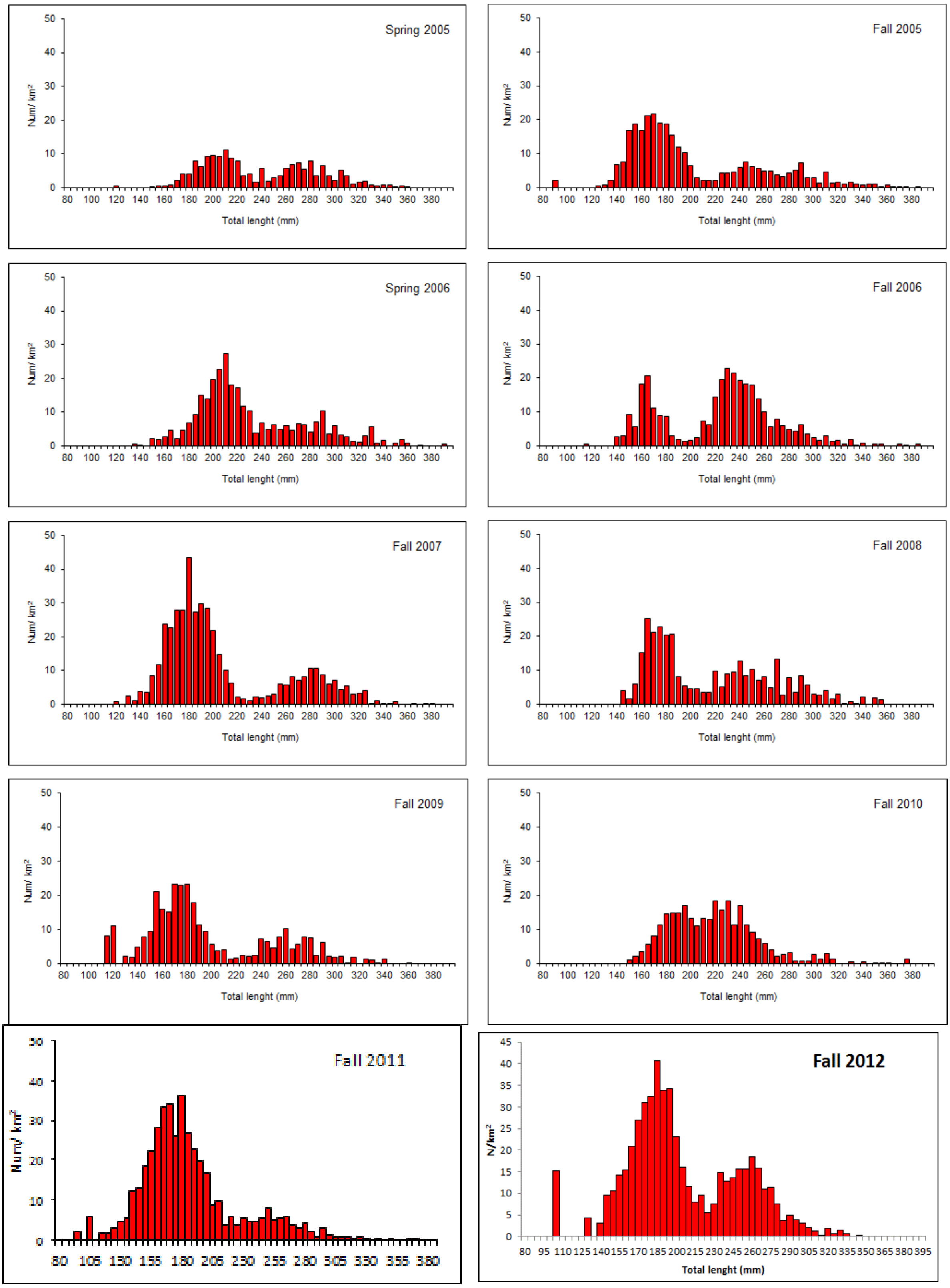


Figure 5.2.5.5.3.1. Common sole in GSA 17. Stratified abundance indices by size, 2005-2014.

Trends in growth
No assessment of trend in growth has been carried out.

Trends in maturity
No assessment of trend in growth has been carried out.

Stock Assessment
Stock assessment has been conducted using 2 methods XSA and Statistical Catch at age using SS3.

5.2.5.1.6 Methods

Method: XSA (Extended Survival Analysis)
FLR libraries were employed in order to carry out an XSA based assessment. The common sole stock in GSA 17 was assessed during EWG 12-02. XSA was carried out using as input data the period 2006-2014 both for the catch data and for the tuning file (SoleMon survey).

Method: SS3
Stock Synthesis 3 provides a statistical framework for the calibration of a population dynamics model using fishery and survey data. It is designed to accommodate both population age and size structure data and multiple stock sub-areas can be analysed. It uses forward projection of population in the "statistical catch-at-age" (hereafter SCAA) approach. SCAA estimates initial abundance at age, recruitments, fishing mortality and selectivity. Differently from VPA based approaches (e.g. by XSA) SCAA calculates abundance forward in time and allows for errors in the catch at age matrices. Selectivity has been generated as age-specific by fleet, with the ability to capture the major effect of age-specific survivorship. The overall model contains subcomponents which simulate the population dynamics of the stock and fisheries, derive the expected values for the various observed data, and quantify the magnitude of difference between observed and expected data. Some SS features include ageing error, growth estimation, spawner-recruitment relationship, movement between areas; in the present assessment such features are not summarized in the results. The ADMB C++ software in which SS is written searches for the set of parameter values that maximize the goodness-of-fit, then calculates the variance of these parameters using inverse Hessian methods. In the present assessment the variance is not shown for fishing mortality results, because the model outputs provide F values (called continuous F) within a year as standardized into selection coefficients by dividing each F value by the maximum value observed for any age class in the year (e.g., Derio et *al.*, 1985; Sampson and Scott, 2011). For a better comparison with the results of previous assessments carried out both in the framework of STECF-EWGs and GFCM-WGs and with the outputs of the XSA carried out in the present assessment, the F values are standardized by dividing by the average (called F_{bar}) of the F values observed over a defined range of age classes (e.g., Darby and Flatman, 1994; Sampson and Scott, 2011).

5.2.5.1.7 Input data

The same SOP corrected data were employed in each method. In the XSA a plus group have been set at age 5, while no plus group has been considered in SS3 model.
SS3 model allowed to specify the different source of data, providing different uncertainties estimates for each data set. Moreover also the total landings presented from 1970 to 2005 (FAO-FishstatJ

source) has been used in the model, together with the DCF and Croatian data for the period 2006-2014 (Table 5.2.5.4.3.2). Also in this case the model considered the different sources of the data sets and treated the error separately for each period. In order to facilitate the convergence of the model a higher number of ages has been employed for natural mortality, fecundity and weight at age. SS3 also accounted for catch at age data by fleet as presented in the table 5.2.5.4.3.3.

Maturity at age and growth parameters were provided in the framework of SoleMon project. Parameters provided from the DCF 2015 official data call were not used in the present assessment for the following reasons:

1. Growth parameters estimates were quite different between Italy and Croatia. Moreover the Italian growth parameters estimates were based mainly from age ranges comprised between 0 and 3.
2. Maturity at age was estimated by Italy only for females, while Croatian estimates were comprised from age 2 to age 4.

Mean weights-at-age were provided by DCF 2015 official data.
Tuning data were provided by SoleMon surveys, carried out in fall for the years 2006-2014.
A vector of natural mortality rate at age was estimated using the PRODBIOM spreadsheet (Abella et al., 1997).

Table 5.2.5.6.2.1. Common sole in GSA 17. Input data. * = catches used for XSA.

Totola catches (tonnes)*	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
	2022	1588	1325	1954	1614	1589	1859	1253	2048
Catch number (x 1000)*	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
0	2872.5	400.3	853.5	5473.3	4808.6	4812.5	7830.4	1487	523.4
1	10219.4	7890.2	7298.3	7128.3	5606.7	6759.4	8719.2	6885.3	12804.6
2	1588.5	1303.1	590.2	850.4	591.8	1105.9	991.5	195.1	1463.4
3	684.2	883.9	427.8	944.8	539.3	671	457.3	1232.3	440.7
4	26.3	29.4	19.1	45.8	26.1	38	22.1	34.1	22
5+	7.8	9.5	6	16.1	10.2	28.4	5.8	9.6	6.2
Weights-at-age (kg)	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
0	0.066	0.066	0.077	0.077	0.079	0.065	0.07	0.066	0.052
1	0.125	0.125	0.133	0.137	0.156	0.116	0.114	0.12	0.128
2	0.186	0.186	0.211	0.224	0.254	0.2	0.181	0.19	0.151
3	0.356	0.356	0.356	0.356	0.356	0.356	0.272	0.22	0.335
4	0.453	0.453	0.453	0.453	0.453	0.453	0.453	0.453	0.453
5	0.522	0.522	0.522	0.522	0.522	0.522	0.522	0.522	0.522
6	0.550	0.550	0.550	0.550	0.550	0.550	0.550	0.550	0.550
Natural mortality	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**

0	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
1	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
2	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28
3	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
4	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23
5	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22
6	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22
Maturity	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
0	0	0	0	0	0	0	0	0	0
1	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
2	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76
3	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
4	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
5	1	1	1	1	1	1	1	1	1
6	1	1	1	1	1	1	1	1	1
SoleMon (n/km^2)	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
0	56.794	74.839	24.006	72.735	15.734	68.051	52.114	181.552	75.713
1	171.276	195.392	109.884	107.035	199.951	246.461	254.453	421.41	608.188
2	82.34	75	72.4	60.39	41.204	45.044	106.983	90.628	213.363
3	8.29	27.75	14.89	7.66	9.122	7.665	10.63	14.91	15.017
4	0.82	3.06	5.25	2.92	1.28	1.417	2.57	3.2	4.63
5	0.17	0.21	1.41	0.24	0.81	0.473	0	0	0.25
6	0	0.37	0	0	1.36	0.42	0	0	0

5.2.5.1.8 Results
Method: XSA

A sensitivity analysis testing different shrinkage weights was performed before running the final XSA (Sh 0.5, 1.0, 2.0). Also, a sensitivity analysis of the rage parameter between 0 and 1 and qage parameter between 3 and 4 was carried out (Figure 5.2.5.6.3.1). The 5 best runs are ranked and summarized in table 5.2.5.6.3.1.

Table 5.2.5.6.3.1. Common sole in GSA17. XSA run comparison: minimum, maximum and average residuals absolute value are ahown as well.

	fse	rage	qage	Min Residual	Max Residual	Average (abs value)
Run 3	**2**	**0**	**4**	**-0.794**	**0.91**	**0.206**
Run 6	2	0	3	-0.789	0.909	0.212
Run 8	1	1	4	-0.967	0.811	0.220
Run 2	1	0	4	-0.893	0.958	0.246
Run 5	1	0	3	-0.891	0.962	0.248

On the base of the sensitivity analyses the XSA run 3 were selected:

- Catchability dependent on stock size for ages = 0.

- Catchability independent of age for ages >= 4.
- S.E. of the mean to which the estimates are shrunk = 2.
- Minimum S.E. for population estimates derived from each fleet = 0.30.
- Number of years used for the shrinkage = 6.
- Number of ages used for the shrinkage = 6.
- Ages used for tuning from the survey = 0-4.
- F_{bar} = 0-4.
- Proportion of M before spawning = 0.
- Proportion of F before spawning = 0.

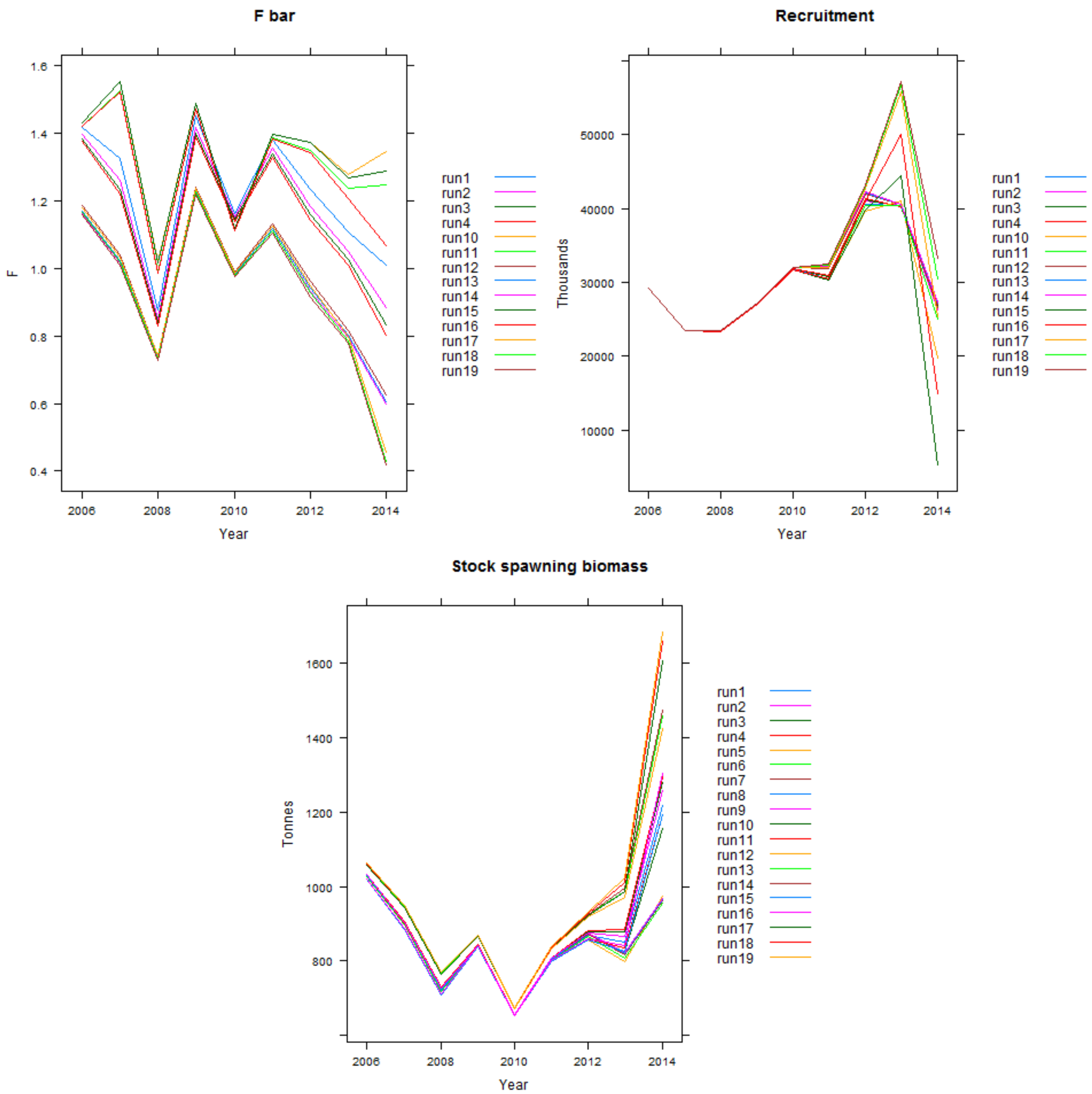


Figure 5.2.5.6.3.1. Common sole in GSA17. XSA run comparison for F, Recruitment and SSB values.

XSA main outputs (Figure 5.2.5.6.3.2 and tables 5.2.5.6.3.2-4) show a decrease in fishing mortality from 2011 till 2014, which is equal to 0.63. Recruitment showed an icreasing trend from 2007 to 2013 followed by a decrease in 2014. SSB showed a stable trens in the period 2006-2013 followed by an increase in 2014 (1,450 tonnes).

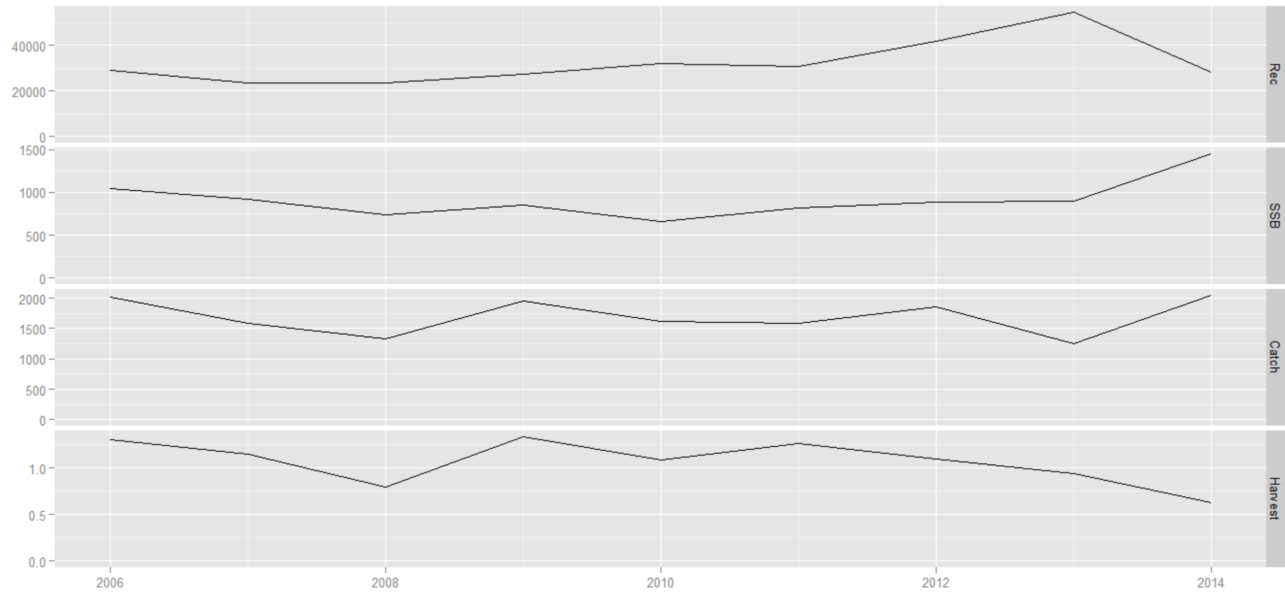


Figure 5.2.5.6.3.2. Common sole in GSA17. XSA summary results. SSB and catch are in tonnes, recruitment in 1000s individuals.

Table 5.2.5.6.3.2. Common sole in GSA 17. F, Recruitment and SSB estimates by XSA from 2006 to 2014.

Year	SSB	Recruitment	Fbar (0-4)
2006	1,040	29,191	1.30
2007	917	23,451	1.15
2008	739	23,361	0.80
2009	850	27,137	1.34
2010	661	31,908	1.09
2011	815	30,893	1.26
2012	888	41,963	1.10
2013	896	54,422	0.94
2014	1,450	28,245	0.63

Table 5.2.5.6.3.3. Common sole in GSA 17. Harvest by age estimates by XSA from 2006 to 2014.

Age	2006	2007	2008	2009	2010	2011	2012	2013	2014
0	0.15	0.02	0.05	0.34	0.24	0.25	0.31	0.04	0.03
1	1.56	1.40	1.45	1.48	1.19	1.04	2.03	0.77	0.88
2	0.82	1.08	0.38	0.73	0.49	0.95	0.46	0.23	0.41
3	2.41	2.47	1.77	3.06	2.26	2.60	1.95	2.83	1.40
4	1.58	0.80	0.35	1.08	1.25	1.46	0.74	0.84	0.45

5+	1.58	0.80	0.35	1.08	1.25	1.46	0.74	0.84	0.45

Table 5.2.5.6.3.4. Common sole in GSA 17. Stock numbers by age estimates by XSA from 2008 to 2014.

Age	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
0	29,191	23,451	23,361	27,137	31,908	30,893	41,963	54,422	28,245
1	15,399	12,472	11,363	10,999	9,619	12,457	11,950	15,320	25,977
2	3,275	2,273	2,165	1,881	1,767	2,072	3,104	1,102	5,016
3	852	1,094	585	1,123	682	821	604	1,484	663
4	37	60	72	78	41	55	47	67	68
5+	11	19	22	27	16	40	12	19	19

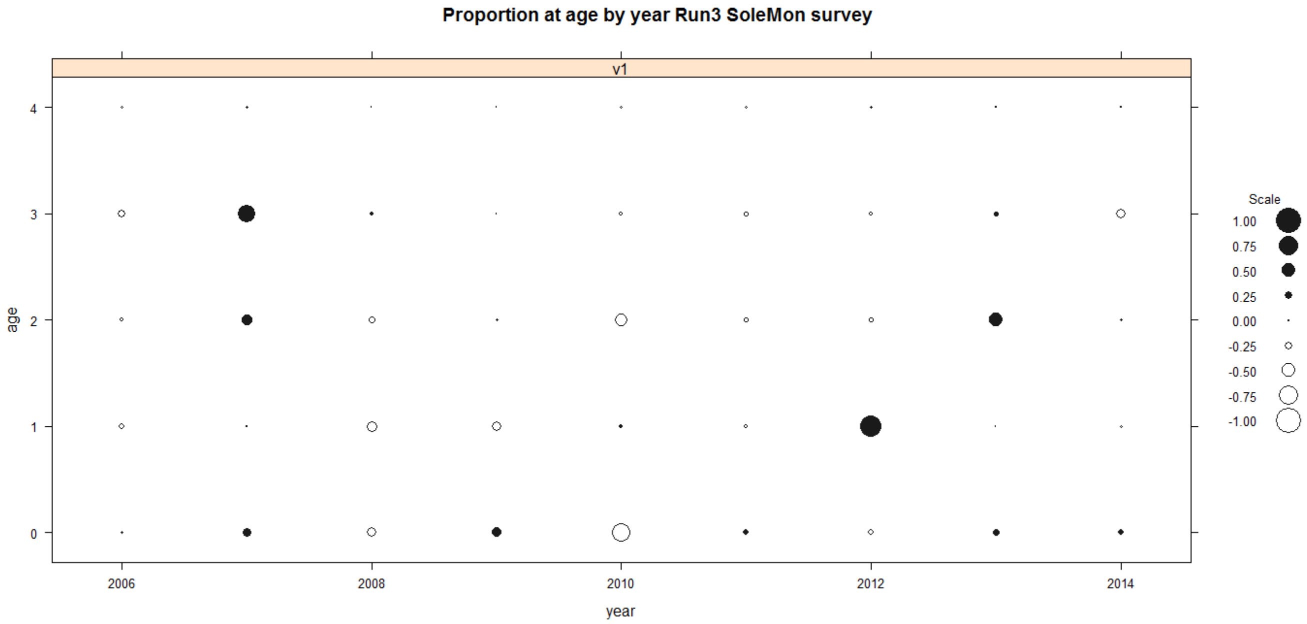


Figure 5.2.5.6.3.5. Common sole in GSA 17. Bubble plot of residuals of for the final model.

Retrospective analysis was carried out and the time series of estimates for assessments terminating in 2014, 2013 and 2012 are plotted. The retrospective series indicate good agreement between years in the assessment results with no systematic bias. The estimates derived from retrospective assessments are plotted in figure Figure 5.2.5.6.3.6.

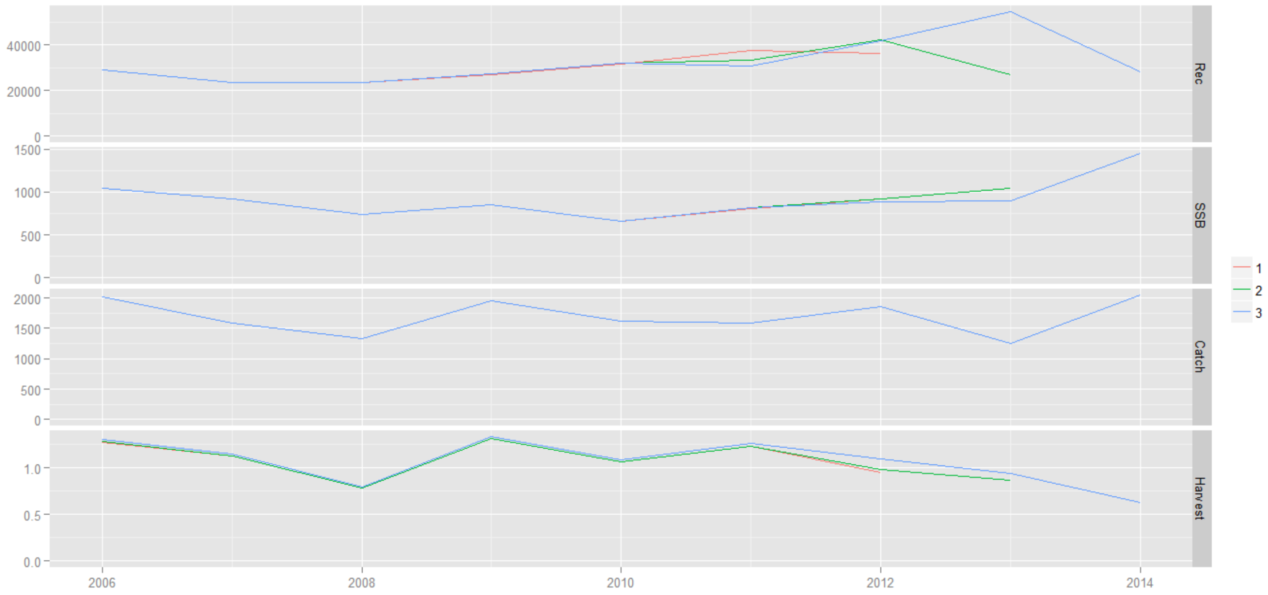


Figure 5.2.5.6.3.6. Common sole in GSA17. Retrospective pattern of the final XSA run for R, SSB and harvest.

Method: SS3

Considering the information provided in previous sections the selectivity patterns of the fleets and the survey have been rescaled as in the Figure 5.2.5.6.3.7.

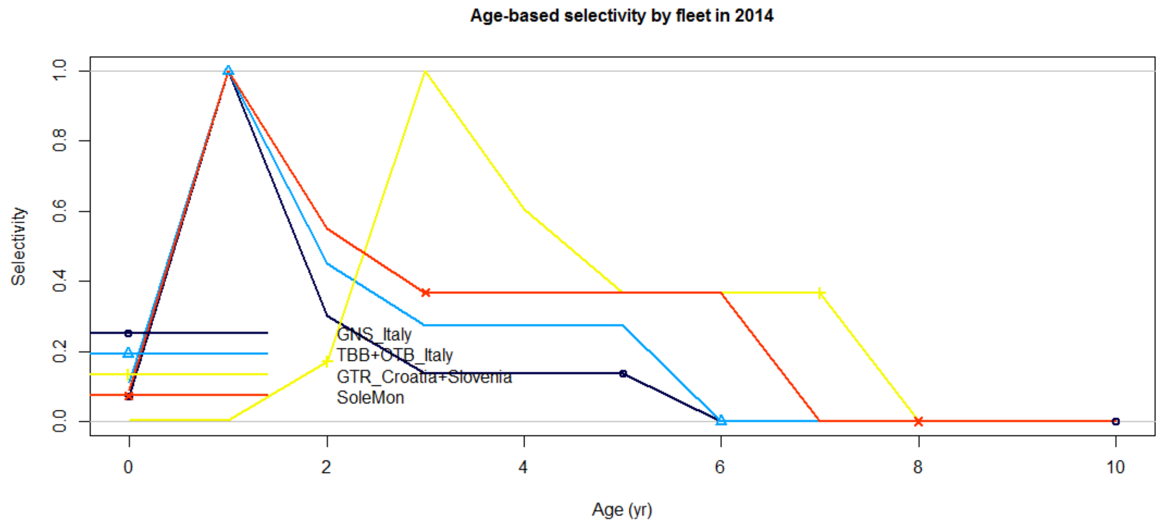


Figure 5.2.5.6.3.7. Common sole in GSA17. Selectivity by age utilized in the SS3 model.

The model residuals by survey and fleet data are shown in Figure 5.2.5.6.3.8.

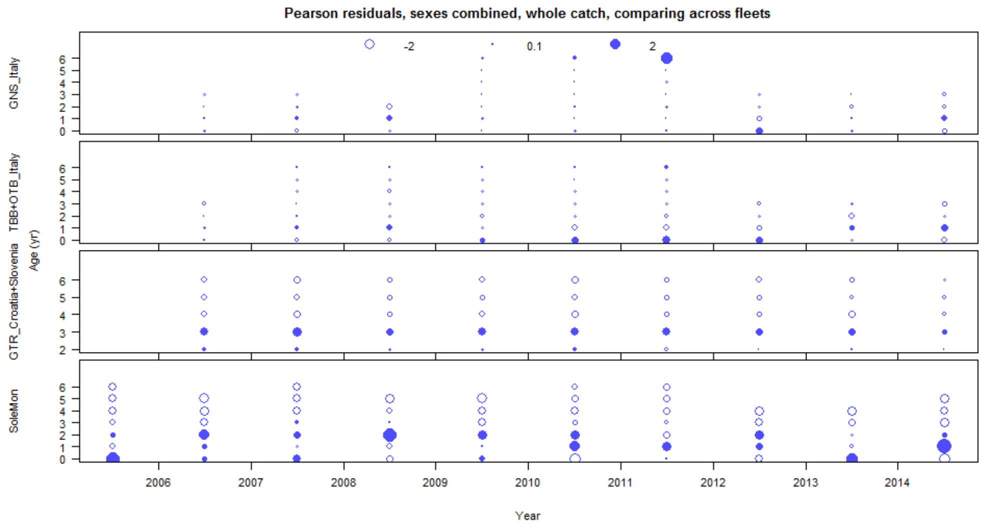


Figure 5.2.5.6.3.8. Common sole in GSA17 Pearson residuals for SoleMon survey and the fleets.

A sensitivity analysis has been conducted assumg different combinations of selectivity for the SoleMon survey and each fleet. The results of the sensitivity analysis are summarized in the table 5.2.5.6.3.5 and figure 5.2.5.6.3.9.

Model	Selectivity assumptions	Log(L)	Hessian matrix convergence	Final gradients	SSB 2014
Final run	Random walk for all the fleets costrained in age > 3	76.94	Yes	6.57E-06	3545
Run 1	SoleMon and Croatian-Slovenian fleets logistic	300.79	Yes	0.00016	3285
Run 2	Croatian-Slovenian fleets logistic	111.019	Yes	6.37E-06	3793
Run 3	Random walk not constrained	18.1	No	-	2.17E+06
Run 4	SoleMon survey logistic	380.211	No	-	5055.67
Run 5	SoleMon and Croatian-Slovenian fleets exponential logistic	134.757	No	-	5.60E+12

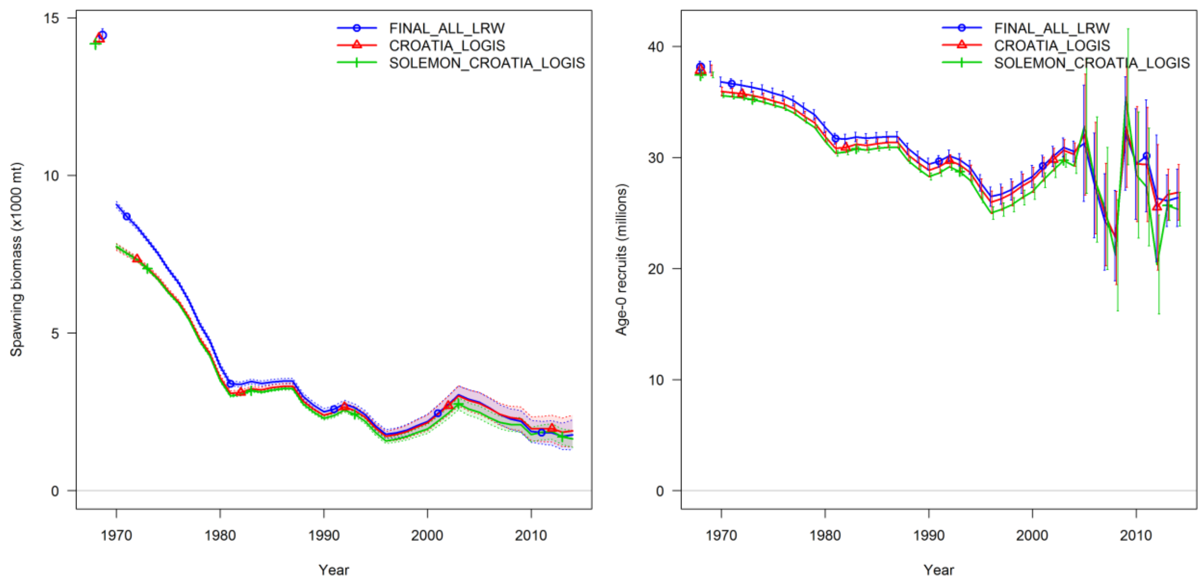


Figure 5.2.5.6.3.9. Common sole in GSA17. SS3 run comparison for Recruitment and SSB values.

Figure 5.2.5.6.3.10 presents the main results from the SS3 run: fishing mortality ($Fbar_{0\text{-}4}$ and by fleet), recruitment and spawning stock biomass (SSB).

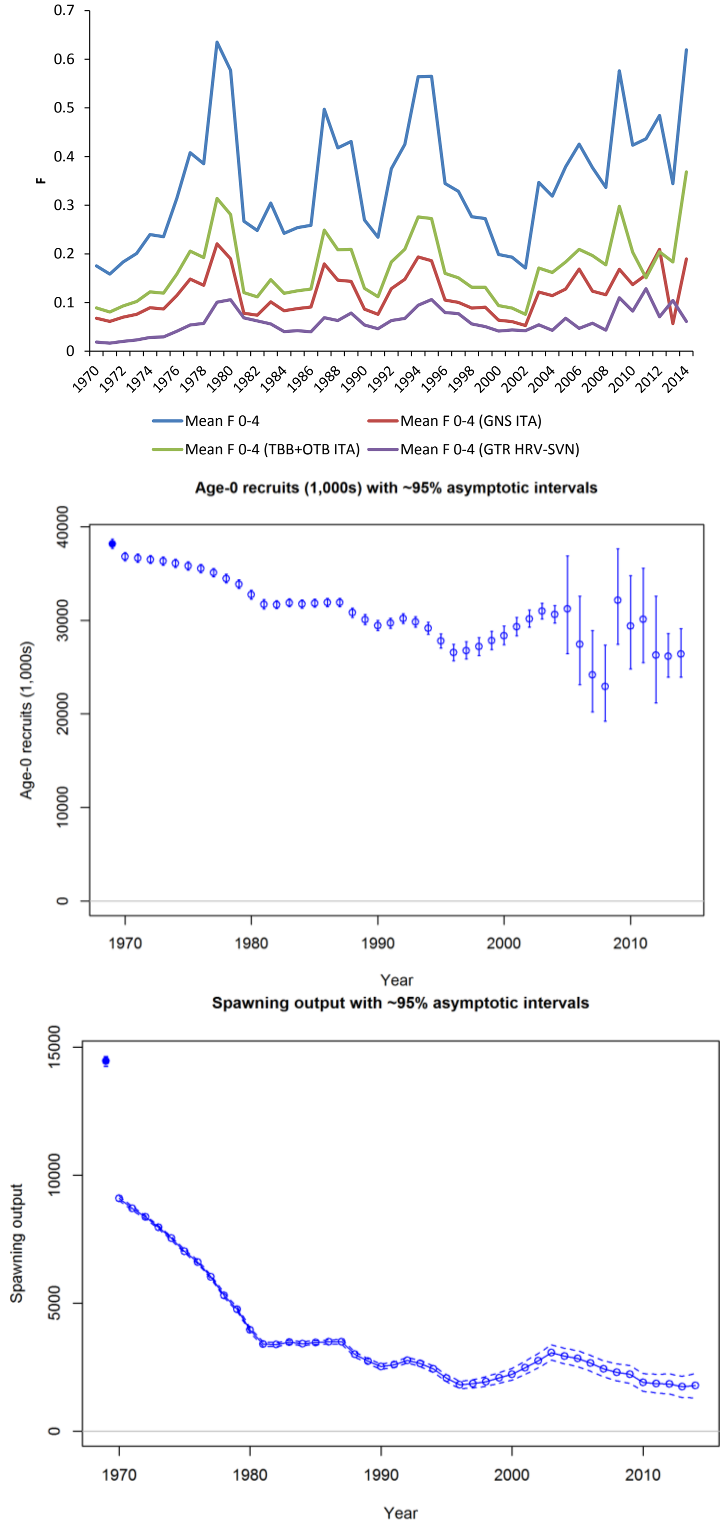


Figure 5.2.5.6.3.10. Common sole in GSA17. Final assessment results SS3 run.

Exploitation increased from the beginning of the time-series, with a more pronounced increase after 2000. In the period 2006-2013 the F_{bar} showed important oscillations around a value of 0.5. In 2014 the value of mean fishing mortality (F_{bar} 0-4) increased toward 0.62, the partial F for each fleet is 0.37 for the Italian trawlers, 0.19 for the Italian gill netters and 0.06 for the Slovenian and Croatian set netters. Recruitment varied without any trend in the years 1970-2012, reaching the minimum in 2008, followed by an increase in 2009; after that there was a general decrease till to 2014. The SSB showed a strong decrease since the beginning of the series. The last estimate of SSB in 2014 is around 3545 tons.

Retrospective analysis was carried out and the time series of estimates for assessments terminating in 2014, 2013, 2012, 2011 and 2010 are plotted. The retrospective series indicate good agreement between years in the assessment results with no systematic bias. The estimates derived from retrospective assessments are plotted in figure Figure 5.2.5.6.3.11.

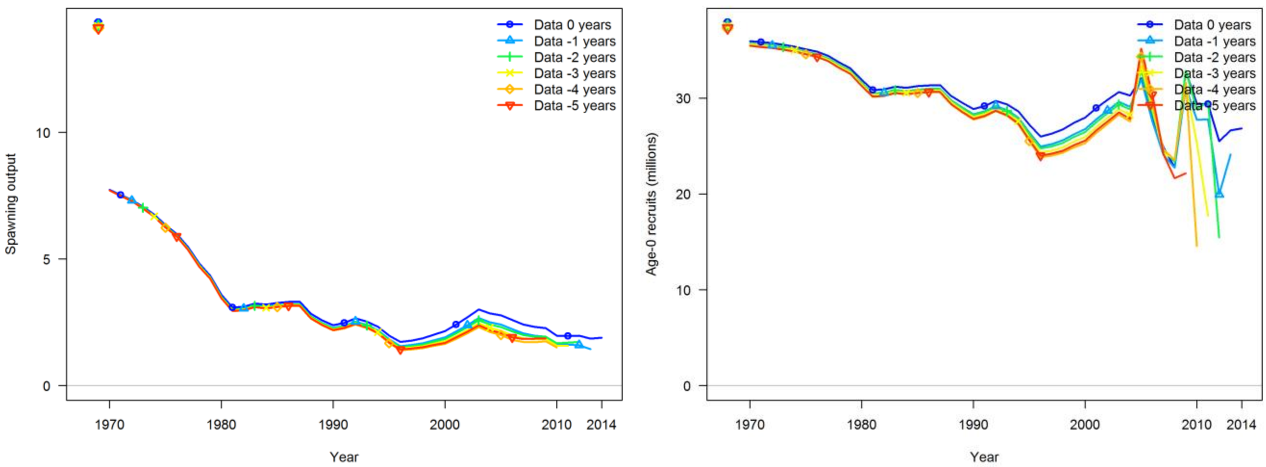


Figure 5.2.5.6.3.11. Common sole in GSA17. Retrospective pattern of the final SS3 run for the main variables (SSB and R).

Finally a jitter analysis changing the initial values of the final model of SS3 has been carried out to test for the stability of the model. Considering that only a low percentage of models provided results out of bound for the 3 main variable (F, Rec and SSB) the model can be considered stable (Figures 5.2.5.6.3.12). It is important to note that this F showed here is not Fbar but apical F.

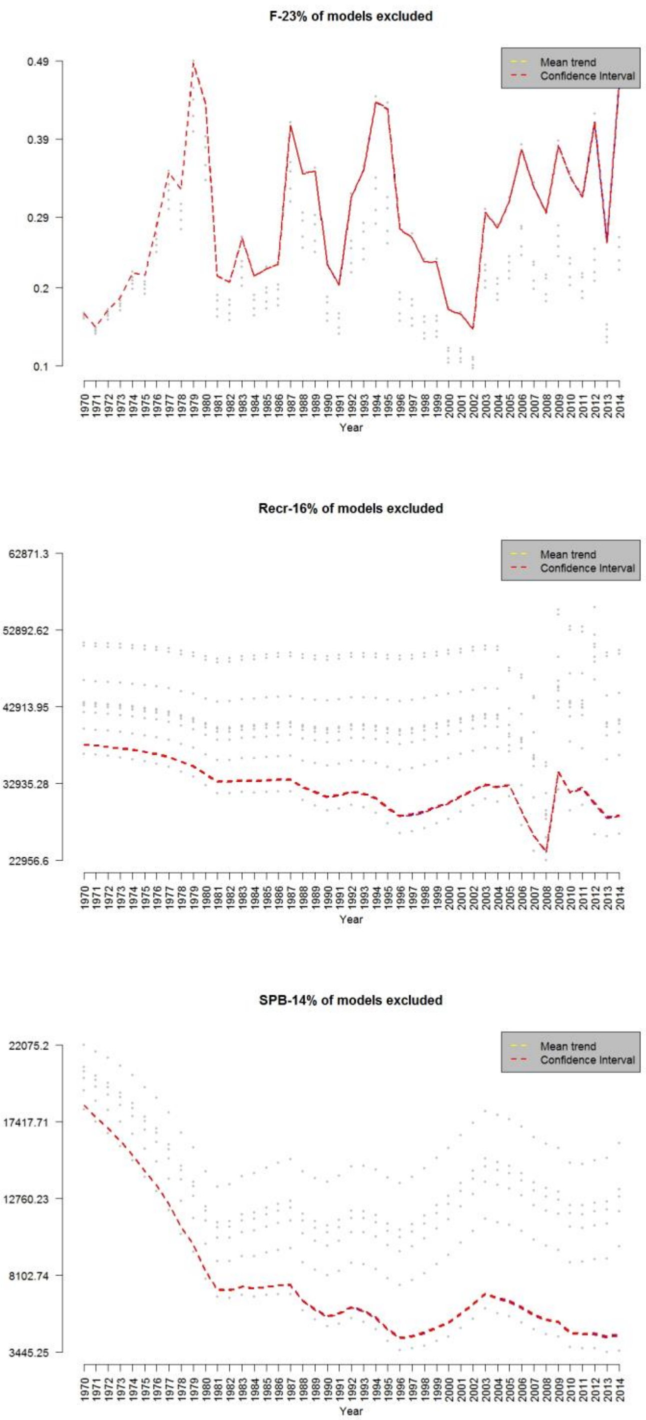
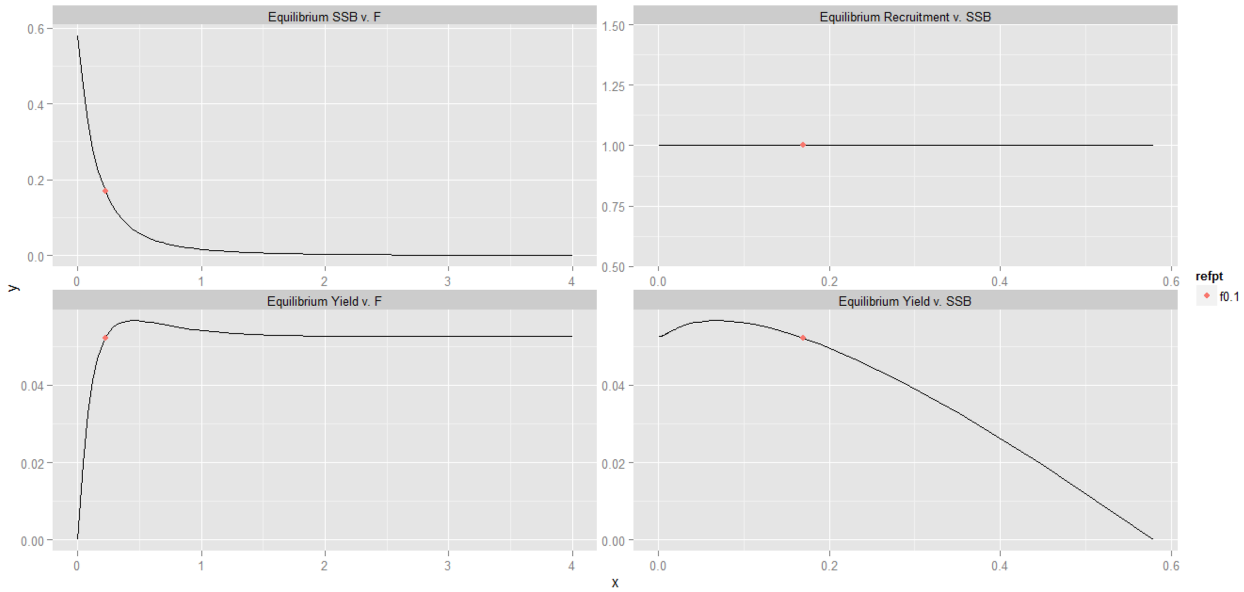


Figure 5.2.5.6.3.12. Common sole in GSA 17. Jitter analysis of the final SS3 run for F, Rec and SSB.

Reference points

Due to the short time series it was not possible to estimate a stock recruitment relationship. As a consequence the biological reference point has been estimated using the Yield per Recruits approach, where $F_{0.1}$ is considered a proxy of F_{MSY}. Biological reference points have been estimated using the XSA and SS3 output data and selectivity patterns.

The results suggest that common sole stock is exploited above F_{MSY} both for the XSA and SS3 (Figure 5.2.5.7.1 and table 5.2.5.7.1).



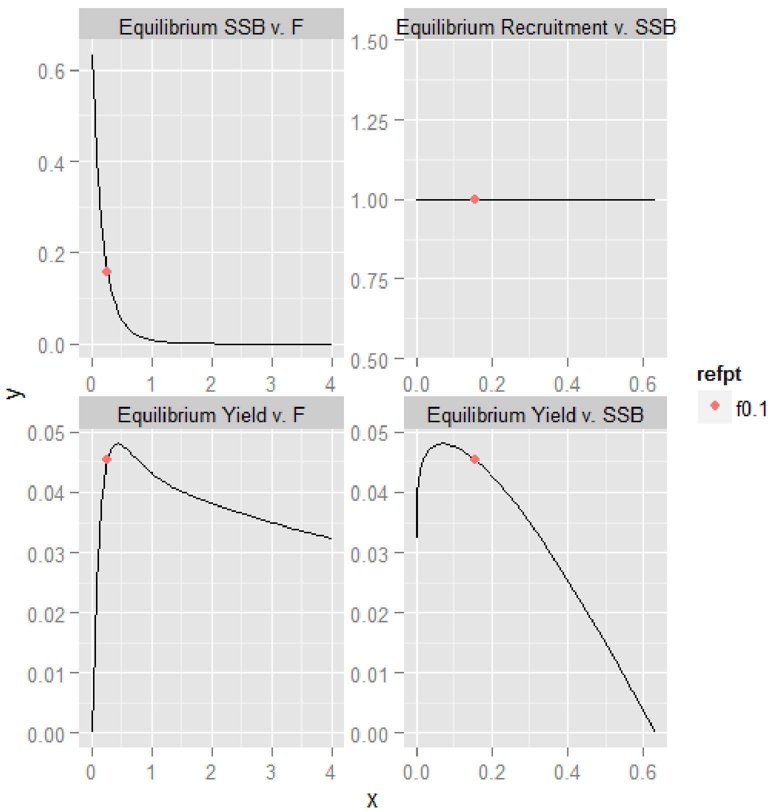


Figure 5.2.5.7.1. Common sole in GSA 17. Yield per Recruit analyses for XSA (above) and SS3 (below).

Table 5.2.5.7.1. Common sole in GSA 17. Yield per Recruit outputs for XSA and SS3.

	Current F ($F_{BAR\ 0-4}$)	Reference Points	Harvest	Yield/R	SSB/R	Total biomass/R
XSA	0.63	$F_{0.1}$	0.22	0.052	0.17	0.229
		F_{max}	0.45	0.057	0.06	0.11
SS3	0.62	$F_{0.1}$	0.26	0.045	0.16	0.21
		F_{max}	0.43	0.048	0.072	0.16

Data quality

With the exception of what reported in section 5.2.5.6.2, no other major issues have been observed in tha data available form the 2015 official DCF data call.

Short term predictions 2016-2018

5.2.9.9.1 Method

A deterministic short term prediction for the period 2015 to 2017 was performed using the FLR routines provided by JRC, based on the results of the SS3 stock assessments performed during EWG 15-16 for the years 2006–2014.

5.2.9.9.2 Input parameters

The same input parameters used in the SS3 analysis showed above were used.

5.2.9.9.3 Results

Recruitment (class 0) has been estimated as the geometric mean of the last 3 years 2012-2014, taken from SS3 results= 26272.2 (thousands).

A short term projection table (Table 5.2.9.9.2.1) assuming a F status quo = 0.48 (average Fbar of last 3 years) in 2015 and a recruitment of 27,006.68 thousand individuals shows that:

- Fishing at F_{status_quo} from 2015 to 2017 would produce an decrease in catches of about 42% and SSB would decrease by 3.6% between 2016 and 2017.
- Fishing at F_{MSY} (026) from 2015 to 2016 would generate a decrease of 63.5% of the catches and an increase of 16.9% in SSB in 2017.
- Catches of common sole in 2016 consistent with FMSY would not exceed 807 tonnes.

Table 5.2.9.9.3.1. Common sole in GSA 17. Short term forecast in different F scenarios. Basis: F(2015) = mean(Fbar0-4 2012-2014)= 0.48; R(2015) = geometric mean of the recruitment of the last 3 years; R = 26,272.2 (thousands); SSB(2014) = 3,545 t, Catch (2014)= 2,212 t.

Rationale	Ffactor	Fbar	Catch 2014	Catch 2015	Catch 2016	Catch 2017	SSB 2016	SSB 2017	Change in SSB 2016-2017(%)	Change in Catch 2014-2016(%)
0 catch	0.00	0.00	2212	1298	0	0	2579	3955	53.3	-100.0
High long term yield ($F_{0.1}$)	0.56	0.26	2212	1298	807	935	2579	3016	16.9	-63.5

Status quo	1.00	0.48	2212	1298	1279	1283	2579	2486	-3.6	-42.2
Scenarios	0.10	0.05	2212	1298	166	226	2579	3759	45.7	-92.5
	0.20	0.09	2212	1298	322	423	2579	3576	38.6	-85.4
	0.30	0.14	2212	1298	468	593	2579	3405	32.0	-78.8
	0.40	0.19	2212	1298	606	741	2579	3246	25.9	-72.6
	0.50	0.23	2212	1298	735	869	2579	3098	20.1	-66.7
	0.60	0.28	2212	1298	857	979	2579	2959	14.7	-61.2
	0.70	0.33	2212	1298	972	1073	2579	2829	9.7	-56.0
	0.80	0.38	2212	1298	1080	1155	2579	2707	5.0	-51.2
	0.90	0.42	2212	1298	1183	1224	2579	2593	0.5	-46.5
	1.10	0.52	2212	1298	1371	1332	2579	2386	-7.5	-38.0
	1.20	0.56	2212	1298	1457	1374	2579	2291	-11.2	-34.1
	1.30	0.61	2212	1298	1539	1409	2579	2202	-14.6	-30.4
	1.40	0.66	2212	1298	1617	1438	2579	2119	-17.8	-26.9
	1.50	0.70	2212	1298	1691	1461	2579	2040	-20.9	-23.6
	1.60	0.75	2212	1298	1761	1479	2579	1966	-23.8	-20.4
	1.70	0.80	2212	1298	1828	1494	2579	1896	-26.5	-17.4
	1.80	0.84	2212	1298	1891	1505	2579	1830	-29.0	-14.5
	1.90	0.89	2212	1298	1952	1513	2579	1768	-31.5	-11.8
	2.00	0.94	2212	1298	2009	1518	2579	1708	-33.8	-9.2

Short term predictions 2015-2017 by fleet

5.2.5.1.9 Method

A deterministic short term prediction by fleet for the period 2015 to 2017 was performed using the FLR routines provided by JRC and based on the results of the SS3 stock assessments performed during EWG 15-16. Three fleets were considered: Italian rapido trawlers and otter trawlers (tbb), Italian small-scale vessels using fixed nets (gns) and Croatian and Slovenian small-scale vessels using fixed nets (gtr).

5.2.5.1.10 Input parameters

The same parameters used in the short term by single fleet were used.

5.2.5.1.11 Results

The main results of the short term predictions by fleet are shown in Table 5.2.5.10.3.1 and Figure 5.2.5.10.3.1. Differently from the XSA results the SS3 model provide the partial F by fleet.

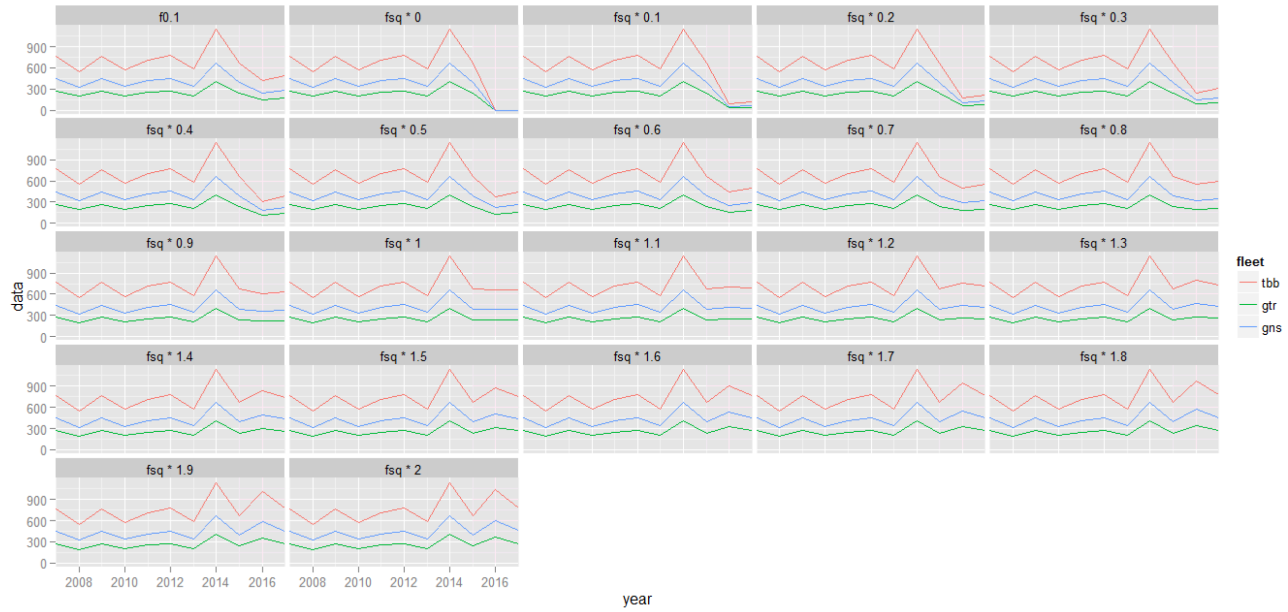


Figure 5.2.5.10.3.1. Common sole in GSA 17. Catches by fleet for different fishing mortality scenarios.

Table 5.2.5.10.3.1. Common sole in GSA 17. Short term forecast by fleet at F_{MSY} ($F_{0.1}$).

Fleet	Year	Catches	Partial F
tbb	2015	670.01	0.23
gtr	2015	237.18	0.08
gns	2015	390.83	0.15
tbb	2016	416.65	0.13
gtr	2016	147.49	0.05
gns	2016	243.04	0.09
tbb	2017	482.50	0.13
gtr	2017	170.80	0.05
gns	2017	281.45	0.09

Medium term predictions

Medium term forecasts were not conducted because no meaningful stock-recruitment relationship was estimated.

Stock advice

SSB shows general stable or increasing trend in the XSA run, while the SS3 model showed a clear decreasing trend of SSB. It is important to point out that the absolute values of XSA are underestimated due to the use of a costant catchability at the older ages. Differently, the SS3 model allows the assumption of a dome-shaped population selection curve, which determines more reliable values of SSB if compared with the historical yields.

According to the XSA analysis the SSB was pratically constant in the period 2006-2013, but in 2014 the estimate showed a remarkable increment; instead SS3 estimates made by SS3 model display a critical situation with a general decreasing trend since 2003. The population is characterized by an SSB which is less than 20% of the 1990s, and demonstrates a clear decreasing pattern of the older

ages. The current SSB estimated with SS3 model is only few tons above Blim (estimated as B_{loss} = 3445 tons).
According to the XSA and SS3 analysis the recruitment of sole in GSA 17 fluctuated since 2006 without a clear increasing or decreasing pattern. The SoleMon survey data show lower values in the last year.
Based on the XSA and SCAA estimates, the fishing mortality in 2014 appears higher than the respective estimates of $F_{0.1}$ and, hence, it can be concluded that the resource is exploited above F_{MSY}.
The group believes that, due to the reasons expressed in paragraph before, the more accurate methodology to assess the stock is SS3. The calculation of reference point has been updated according to the new methodology applied and the value proposed is $F_{0.1} \leq 0.26$ as proxy for F_{MSY}.

Considering the overexploited situation and the low values of SSB and biomass of the sole stock in GSA 17 a reduction of fishing effort and an improvement in exploitation pattern is advisable, especially of Italian rapido trawlers and gillnetters, which mainly exploit juveniles. The best option to reduce effort and improve the exploitation pattern for sole in GSA 17, would be to introduce a closure for rapido trawling within 17 km (9 nm) of the Italian coast during the summer-fall period (June- December) as observed in the spatial simulation, as reported in Scarcella et al. (2014). Moreover, it was noted that in the last years some Italian artisanal fleets fish with gill net in the main spawning area during periods when trawling is prohibited. Additional measures to restrict exploitation of sole in the spawning area are desirable, to afford further protection to the Adriatic sole stock. Safeguarding this area (identified by the SoleMon trawl survey, Grati *et al.*, 2013) to prevent a dramatic increase of the fishing pressure both of *rapido* trawlers and set netters might be crucial for the sustainability of the Adriatic sole stock. Moreover in order to have a more accurate estimation of the tuning data it is extremely important to extend the SoleMon survey also inside the Croatian waters.

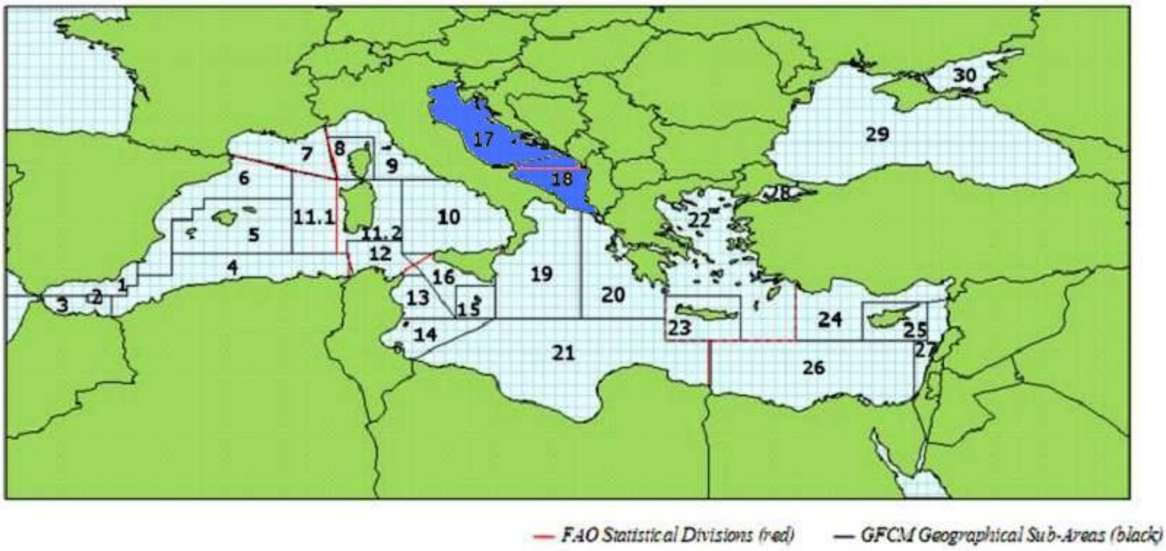
Management strategy evaluation
A Management Strategy Evaluation was run to evaluate if the MSY ranges were precautionary. The F_{MSY} ranges were derived using the formula provided by STECF EWG 15-09. F ranges results were F_{upper}=0.36 and F_{lower}=0.18. B_{lim} was estimated as B_{loss}= 3,445 (t).
No meaningful results were obtained from the MSE outputs and thus the analysis was not considered valid.

5.2.6 STOCK ASSESSMENT OF NORWAY LOBSTER IN GSA 17-18

Stock Identification

Nephrops norvegicus is a sedentary long-lived, slow growing lobster which inhabits burrows constructed in muddy substrates of the upper slope and its presence appears to be related with heterogeneity in the characteristics of the sediment as well as with variations in fishing effort. In the Adriatic Sea, the species has been recorded at depths from about 30 m depth in the north to 400 m in the south (Marano et al., 1998). In the southern Adriatic, both along the western (Italian) and eastern (Albanian) coasts, the settlements are not as dense as in northern part (Karlovac, 1953; Marano et al., 1998).

The geographic distribution of *Nephrops norvegicus* is generally highly discontinuous because heavily dependent upon sediment composition which should be muddy and preferably medium-grained (~ 40% of clay and silt) (Farmer, 1975; Afonso-Dias, 1998; Bell et al., 2007). Importantly, there seems to be a stock-specificity to the relationship between burrow density and sediment composition which has been found to hold true over time (Campbell et al., 2009). This, added to the fact that *Nephrops* is a sedentary species (Chapman & Rice, 1971), means that this species is generally characterised by spatially segregated populations (or “stocks”) with little or no exchange between them in the adult phase, while on the other hand the larvae have a pelagic phase of 2-7 weeks (Bell et al., 2007). This heterogeneity in distribution is also present within smaller areas, giving rise to smaller “sub-populations” or “stocklets” with different densities and life-history characteristics (Maynou & Sardà, 1997; Bell et al., 2007)



01 - Northern Alboran Sea	07 - Gulf of Lions	13 - Gulf of Hammamet	19 - Western Ionian Sea	25 - Cyprus Island
02 - Alboran Island	08 - Corsica Island	14 - Gulf of Gabes	20 - Eastern Ionian Sea	26 - South Levant
03 - Southern Alboran Sea	09 - Ligurian and North Tyrrhenian Sea	15 - Malta Island	21 - Southern Ionian Sea	27 - Levant
04 - Algeria	10 - South and Central Tyrrhenian Sea	16 - South of Sicily	22 - Aegean Sea	28 - Marmara Sea
05 - Balearic Island	11.1 - Sardinia (west) 11.2 - Sardinia (east)	17 - Northern Adriatic	23 - Crete Island	29 - Black Sea
06 - Northern Spain	12 - Northern Tunisia	18 - Southern Adriatic Sea	24 - North Levant	30 - Azov Sea

Fig. 5.2.6.1.1. Norway lobster in GSA 17-18. Geographical location of GSAs 17 and 18 (blue-shaded area).

The object of this chapter is the assessment of *Nephrops* in GSAs 17 and 18 (Adriatic Sea; Fig. 5.2.6.1.1).

Numerous studies carried out in GSA 17 have highlighted that *Nephrops* has different growth rates and sizes at first maturity within different areas of GSA 17, and these are, in turn different to the faster growth reported for GSA 18 (see section 5.2.6.2). The MEDISEH project (Mediterranean Sensitive Habitats, 2013) used Zero Inflated General Additive Modelling to identify one prevalent nursery area (R1) and four prevalent spawning grounds (S1 – S4) in GSA 17 (Fig. 5.2.6.1.2). The Pomo/Jabuka pit area is of particular interest as it was identified as both a nursery area (R1) and a spawning ground (S1; Fig. 5.2.6.1.2).

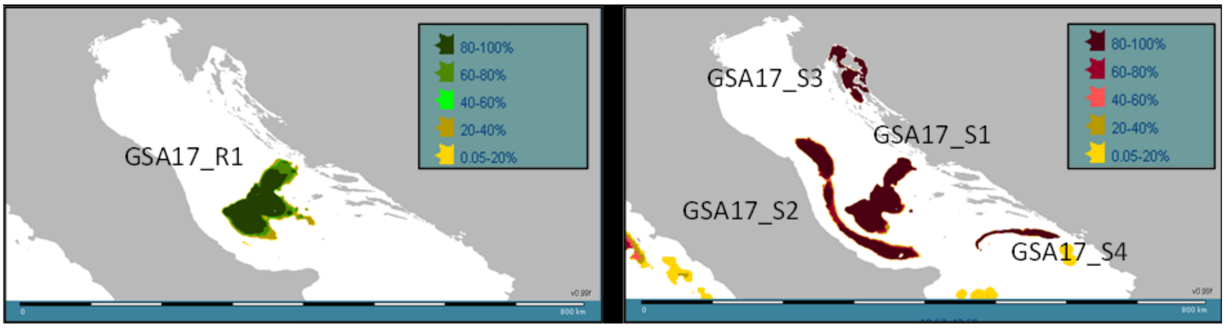


Fig. 5.2.6.1.2. Norway lobster in GSA 17-18. Position of persistent nursery (left) and spawning areas (right) in GSA 17 of as identified by the MEDISEH project (Mediterranean Sensitive Habitats, 2013).

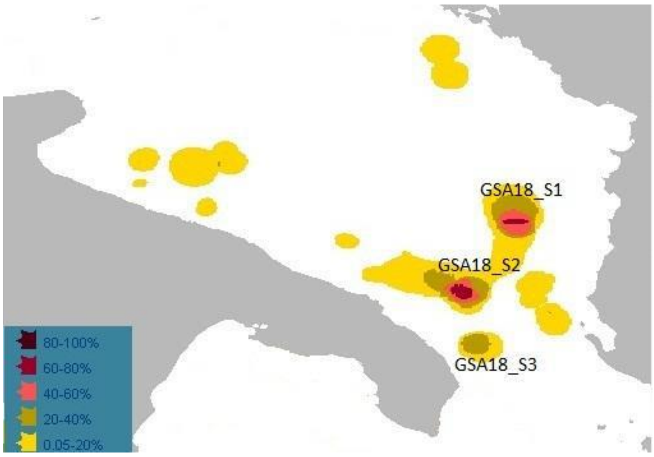


Fig. 5.2.6.1.3. Norway lobster in GSA 17-18. Position of persistent spawning areas in GSA 18 of as identified by the MEDISEH project (Mediterranean Sensitive Habitats, 2013).

The reality is that the individuals characterising the nursery area are unlikely to be true recruits as the Pomo/Jabuka pit, for reasons related to its geography, morphology and oceanography, is likely to be inhabited by a very dense “subpopulation” of smaller animals with slower growth rates (see section 5.2.6.2) (Froglia and Gramitto, 1981; Froglia and Gramitto, 1988; IMBC et al., 1994). As a result the Pomo/Jabuka pit “subpopulation” should be considered as separate from the other grounds off the eastern Italian coast south of Ancona (S2, Fig. 5.2.6.1.2; Froglia and Gramitto, 1981, Froglia and Gramitto, 1988, IMBC et al., 1994), in the northern Croatian channels (S3, Fig. 5.2.6.1.2; Vrgoč et al., 2004) and in GSA 18. Genetic analyses have not revealed differences between the “Ancona subpopulation” and the “Pomo/Jabuka subpopulation” that go beyond the population level, allowing the inference that the differences in growth and maturity may be predomintantly due to environmental factors (Mantovani and Scali, 1992). Currently, further investigations are being carried out using modern genetic techniques.

The same project identified a number of persistent spawning areas in GSA 18 (Fig. 5.2.6.1.3). In the South Adriatic, highly persistent (60-80% probability) hot spots of Norway lobster adult females are found in the Otranto channel, along the border of the South Adriatic pit, both on the eastern (GSA 18_S1) and western (GSA18_S2 and GSA18_S3) sides, down 200 m depth (Fig. 5.2.6.1.3). In GSA 18 higher abundances of Norway lobster were localized offshore Molfetta and Brindisi, along the central-western side of the GSA (Lembo et al., 2010).

From a biological point of view, on the basis of the above information, it appears that treating the *N. norvegicus* population in GSA 17 as one single stock unit/functional unit may be questionable and could lead to an inaccurate and imprecise evaluation of the status of the resource. Ideally an assessment should be carried out considering two stock units (i.e. two separate assessments) or using models that assume one stock unit with different morphs (with limited exchange). In this instance, this was not possible for the main reason that official data (catches, landings and survey indices) are not available for split areas within GSA17.

In the north-east Atlantic *N. norvegicus* stocks are managed by Total Allowable Catch advised annually by ICES (ICES, 2003). Although TACs are delivered for aggregated areas (ICES sub-divisions), all advice is based on small Management Areas or Functional Units taking into account the poor connectivity between stocks and the possibility of different life history characteristics (Ungfors et al., 2013). It is also important to note that in the ICES area, landings are split using ALK which are estimated at smaller scales than the stock assessment area. In other words, if there are spatial variations in growth within a stock, these are accounted for when the catch at age matrix is generated by using spatially specific growth functions/ALK (Ungfors et al., 2013).

Growth

Norway lobster is characterised by discontinuous growth, with moults interspersed by intermoult periods and growth only occurring during the latter period. In the Mediterranean, Norway lobster juveniles moult year-round but adult females only have one growing period per year, in December – March, soon after hatching; in the Adriatic Sea the moulting peak for males is between June and September (Gramitto, 1998). Whilst juveniles of both sexes have similar growth curves, those of mature animals differ, resulting in males growing to be larger than females (Vrgoč et al., 2004; Bell et al. 2007). Information for the spawning prevalence area identified in the Croatian northern channels is yet to be retrieved, but growth rates have been reported to differ markedly between the Pomo/Jabuka pit (S1, Fig. 5.2.6.1.2) and the area off and south of Ancona (S2, Fig. 5.2.6.1.2). The variability in growth rates within the same biological population is likely due to a number of interacting factors (from temperature to sediment composition, food availability and population density and more); pinpointing the exact causal relationship is impossible and area-dependent (Tully & Hillis, 1995; Tuck et al., 1997, Bell et al., 2007). In addition to GSA 17, this has also been found in the Clyde (west Scotland; Tuck et al., 1997) and in south and south-west Portugal (de Figueiredo, 1984).

The growth parameters used in this assessment, along with the relevant length-weight relationships, are summarised in Table 5.2.6.2.1. The growth parameters used for GSA 17 are an average of those reported by Froglia and Gramitto (1988) for the Pomo pit and the area off Ancona; those used for GSA 18 are those reported in DCF data. The parameters for the length-weight relationships for both GSAs are derived from DCF data.

It should be noted that, due to the lack of a reliable method for the determination of *N. norvegicus* age, growth curves for this species have to be established using indirect methods. This relies either on the progression of modes in length-frequency distributions, or on tagging animals or on captivity experiments; all these alternatives have some serious shortcomings (Bell et al., 2007). This adds to the complications provided by the fact that growth is discontinuous and sex- and stage-dependent with different parameters describing adult males and females, as well as pre- and post-maturation females. The commonly used Von Bertalanffy growth function, in the case of *N. Norvegicus*, thus has a number of shortcomings related to the shape of the growth curve at different life stages, in particular for females. This has prompted the ICES Working Group on *N. norvegicus* to assess the species using a “combined” growth curve for females whereby the growth of immature females (up to the size at 50% maturity) is represented by the male growth curve while that of mature females by the female growth curve (Bell et al., 2007). This is of particular relevance in assessments, such as this one, that require the conversion (“slicing”) of catches at length into catches at age based on the assumed Von Bertalanffy growth function (Bell et al. 2007, Dobby & Hillary, 2008). Future data collection may have to take this into account when providing growth curves from landings samples.

Table 5.2.6.2.1. Norway lobster in GSA 17 and 18. Growth parameters and length-weight parameters for males (M), females (F) and combined (C) sexes in GSAs 17 and 18.

	GSA17			GSA18		
	M	F	C	M	F	C
Linf (mm)	61.774	47.767	54.770	80.000	61.000	70.500
k	0.378	0.528	0.453	0.170	0.190	0.180
t0	-0.009	0.050	0.021	-0.500	-0.500	-0.500
a (mm)	0.00055	0.00075	0.000575	0.000438	0.000513	0.000475
b	3.09825	3.021425	3.091	3.139	3.097	3.118

Maturity

Studies on the maturity cycle of Norway lobster have highlighted that the maturity process is completed from late-spring/summer through autumn and the smallest ovigerous female was 23.5 mm carapace length (CL). Records from literature report different lengths at first maturity (Lm_{50}) according to the area considered:

- GSA 17 – Pomo Pit: ~ 26 mm CL (Froglia and Gramitto, 1979; Gramitto and Froglia, 1980; Froglia and Gramitto, 1981; IMBC et al., 1994; Orsi Relini et al., 1998; DCF data);
- GSA 17 – outside Pomo Pit: ~30 – 32.5 mm CL (Froglia and Gramitto, 1979; Gramitto and Froglia, 1980; Froglia and Gramitto, 1981; IMBC et al., 1994; Orsi Relini et al., 1998);
- GSA 18: between 25 mm and 34.8 mm CL, depending on the year (Marano et al., 1998a; Ungaro et al., 1999; DCF data).

These sizes generally correspond to 2 or 3 years of age (Froglia & Gramitto, 1981; Orsi Relini, 1998).
In the Adriatic, *N. norvegicus* spawns once a year (Froglia and Gramitto, 1981). The proportion of females with mature ovaries peaks in spring or at the beginning of summer. Berried females peak in October and November (Orsi Relini et al., 1998), but can be found earlier (from August) and later (until March) (Froglia and Gramitto, 1981). This is important when assessing a *Nephrops* stock because the availability of berried females to the trawl net is much diminished as these animals tend to spend a considerable portion of their time within their burrows (Marrs et al., 2000; Bell et al.,

2007) – the sex ratio in the catches thus changes dramatically over the year (Jukić, 1971; Froglia and Gramitto, 1981; Ungaro et al., 1999). To take this into account, the assessment of *Metanephrops challengeri* in New Zealand comprises two different time steps (Tuck and Dunn, 2012).
According to Karlovac (1953), Norway lobster larvae are present in the Adriatic plankton in late winter, from January to April. The duration of the larval stage has been reported to be temperature-dependent spanning from 3 weeks to 7 weeks (Farmer, 1975; Orsi Relini et al., 1998; Dickey-Collas et al., 2000).
The maturity ogive for females estimated within DCF for GSA 18 yields an L50 of 23.8 mm CL and maturity range 1.51 mm (Fig. 5.2.6.3.1). In this case females from stage 2b (i.e. MEDITS maturity scale) onwards were considered mature.
The sex ratio highlighted a prevalence of males in the higher size classes.

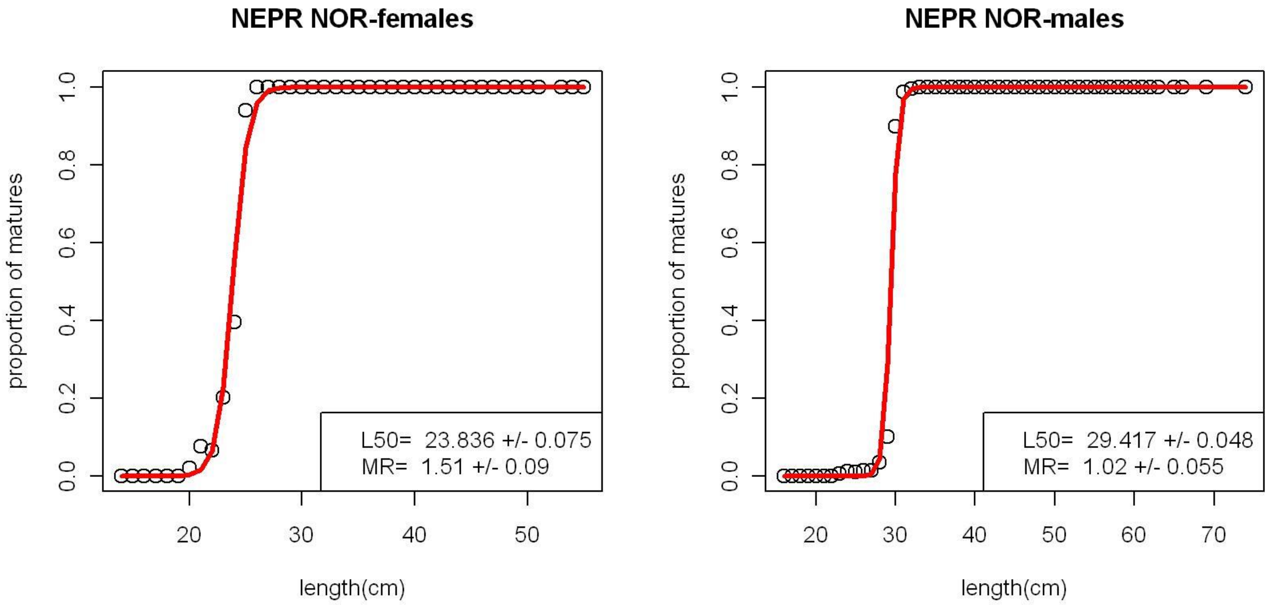


Fig. 5.2.6.3.1. Norway lobster in GSA 17 and 18. Maturity ogives of males and females in GSA 18.

The proportions mature at age for males and females combined derived from DCF sampling in GSA 18 were used for both GSAs (Table 5.2.6.3.1).

Table 5.2.6.3.1. Norway lobster in GSA 17 and 18. Proportions mature at age.

Age	0	1	2	3	4	5	6	7
Prop mature	0.006	0.319	0.954	1	1	1	1	1

Natural mortality

Vectors of natural mortality were calculated using the Prodbiom (Abella et al., 1997) based on the VBGF and length weight relationships reported in Table 5.2.6.4.1 for combined sexes for each GSA.

Table 5.2.6.4.1. Norway lobster in GSA 17 and 18. Natural mortality vectors.

Age	0.5	1.5	2.5	3.5	4.5	5.5	6.5	7.5
GSA17	1.2921879	0.5834461	0.4416978	0.3809485	0.3471989	0.3257219	0.3108532	0.2999495
GSA18	0.6812684	0.2918783	0.2140003	0.180624	0.1620817	0.150282	0.1421129	0.1361223

Fisheries

5.2.6.1.1 General description of the fisheries

Nephrops norvegicus in GSA 17 is exploited prevalently by means of bottom trawls and to a lesser extent in smaller areas such as the northern-eastern Adriatic channels, by means of baited traps. These gears sample different portions of the population: trawls will only catch individuals when they happen to be outside of their burrows, whilst the bait in traps entices animals out of their burrows meaning they can also catch berried females (Morello et al., 2009).

In GSA 18, Norway lobster is only targeted by trawlers on offshore fishing grounds.

It usually occurs with other important commercial species as *Merluccius merluccius*, *Illex coindetii*, *Eledone cirrhosa*, *Lophius* spp., *Lepidorhombus boscii* and *Parapenaeus longirostris* (mainly in GSA 18).

5.2.6.1.2 Management regulations applicable in 2015

Management regulations are based on technical measures, closed number of fishing licenses for the fleet and area limitation (distance from the coast and depth). In order to limit the over-capacity of the fishing fleet, Italian fishing licenses have been fixed since the late 1980s and the fishing capacity has been gradually reduced. Other measures on which the management regulations are based are technical measures (mesh size), minimum landing sizes (EC 1967/06) and a seasonal fishing ban (30 – 45 days per year at variable months in summer), that in the Adriatic has been mandatory since the late 1980s. The minimum landing size of Nephrops is 20 mm carapace length or 70 mm total length. Trawl net cod end mesh size 40 mm (stretched) diamond meshes or a cod end with 50 mm (stretched) square meshes. Towed gears are not allowed within three nautical miles from the coast or at depths less than 50 m when this depth is reached at a distance less than 3 miles from the coast. In 2008 a management plan was adopted, that foresaw the reduction of fleet capacity associated with a reduction of the time at sea. Two biological conservation zones (ZTB) were permanently established in 2009 (Decree of Ministry of Agriculture, Food and Forestry Policy of 22.01.2009; GU n. 37 of 14.02.2009) along the mainland, offshore Bari (180 km2, between about 100 and 180 m depth), and in the vicinity of Tremiti Islands (115 km2 along the bathymetry of 100 m) on the northern border of the GSA where a marine protected area (MPA) was established in 1989. In the former, only the professional small scale fishery using fixed nets and long-lines is allowed, from January 1st to June 30, while in the latter the trawling fishery is allowed from November 1st to March 31 and the small scale fishery is allowed all year round. A recreational fishery using no more than 5 hooks is allowed in both areas. Since June 2010, the rules implemented in the EU regulation (EC 1967/06) regarding the cod-end mesh size and the operative distance of fishing from the coast are also enforced.

In GSA 17, since 26 July 2015 an area corresponding to the Pomo/Jabuka pit (Fig. 5.2.6.5.2.1) has been closed to all trawling fisheries (otter trawling, pair otter trawling and beam traling) for a period of one year, until 26 July 2016. This closure was decided among all countries exploiting this area; mainly Italy and Croatia.

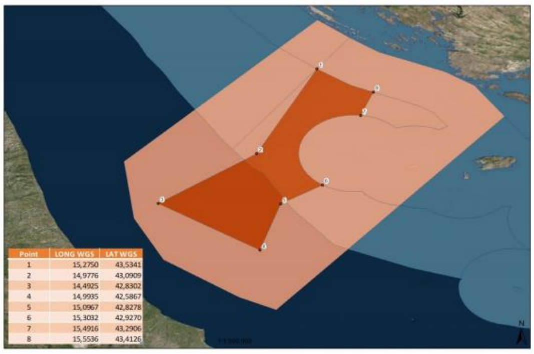


Fig. 5.2.6.5.2.1. Norway lobster in GSA 17 and 18. Map of the Pomo Pit area closed to bottom trawling activity (dark orange polygon).

Numerous regulations have been adopted in Croatia to regulate the technical characteristics of fishing gears and their use with regards to commercial, small-scale and sport fishing. An Ordinance of 1996 on commercial fishing (46/96) prescribes, according to the type of license granted to a vessel, the quantities and types of gear that can be carried on board and used from that vessel. Mesh sizes of nets and other fishing gears as well as their area and time of use have also been determined in Regulations on Commercial Fishing of 2000 (83/2000). Since its entrance in the EU, Croatian fisheries too are subjected to EU fisheries regulations, as described above. Furthermore, bottom trawl fisheries are to operate outside 1.5 NM from the coast and islands in inner sea, 2 NM around islands in the open sea, and 3 NM around several island in the central Adriatic. The bottom trawl fishery is also banned in the majority of channel areas and bays. About 1/3 of the territorial waters is closed to bottom trawl fisheries over the whole year and additionally 10% is closed between 100-300 days per year. For vessels smaller than 15 m, according a derogation, in waters deeper than 50 m bottom trawl fisheries are forbidden up to 1NM of the coast. Prior to EU regulations, the minimum mesh size of bottom trawl net was 20 mm ("knot to knot") in the open sea, and 24 mm ("knot to knot") in the inner sea.

In Montenegro, management regulations are based on technical regulations, such as mesh size (Official Gazette of Montenegro, 8/2011), including the minimum landing sizes (Official Gazette of Montenegro, 8/2011), and a regulated number of fishing licenses and area limitation (no–fishing zone up to 3 NM from the coastline or 8 NM for trawlers of 24+ m LOA). Currently there are no MPAs or fishing bans in Montenegrin waters.

In Albania, a new law "On fishery" has now been approved, repealing the Law n. 7908. The new law is based on the main principles of the CFP, it reflects Reg. 1224/2009 CE ; Reg.1005/2008 CE; Reg. 2371/2002 CE; Reg. 1198/2006 CE; Reg. 1967/2006 CE; Reg. 104/2000; Reg. 1543/2000 as well as the GFCM recommendations. The legal regime governing access to marine resources is being regulated by a licensing system. Regarding conservation and management measures, minimum legal sizes and minimum mesh sizes is those reflected in the CE Regulations. Albania has already an operational vessel register system. It is forbidden to trawl at less than 3 nautical miles (nm) from the coast or inside the 50m isobath when this distance is reached at a smaller distance from the shore.

5.2.6.1.3 Landings

The trawl fishery for *N. norvegicus* in GSA 17 is characterised by decreasing landings for Italy, while Croatian landings have been relatively stable and much lower (Table 5.2.6.5.3.1; Fig. 5.2.6.5.3.1). Landings of the Croatian trap fisheries have been stable and low (around 20 tonnes per year) in the past seven years (Table 5.2.6.5.3.1; Fig. 5.2.6.5.3.1).

Landings of the trawl fishery in GSA 18 have been characterised by a fluctuating decreasing trend (Table 5.2.6.5.3.1; Fig. 5.2.6.5.3.1).

Table 5.2.6.5.3.1. Norway lobster in GSA 17 and 18. Landings by métier and GSA.

Year	FPO HRV	OTB HRV	ITA OTB	GSA 17	GSA 18	Total
2008	23	324	1270	1617	1003	2620
2009	23	342	1379	1744	1093	2837
2010	19	305	1216	1540	1023	2564
2011	20	260	937	1217	759	1977
2012	17	228	802	1047	459	1506
2013	21	278	607	906	834	1740
2014	15	325	529	869	445	1313

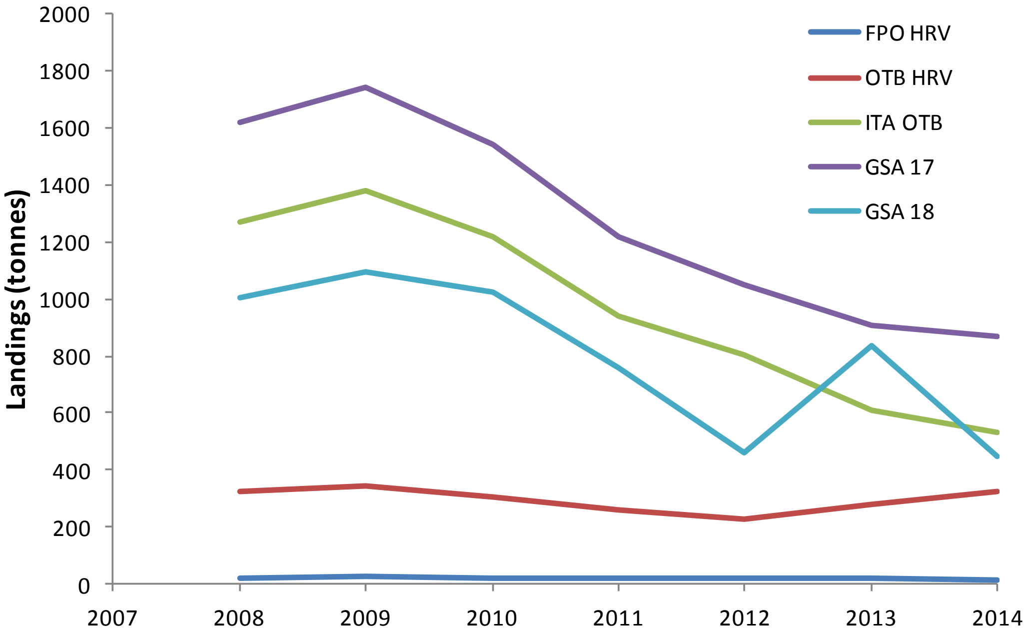


Figure 5.2.6.5.3.1. Norway lobster in GSA 17 and 18. Landings by métier and GSA.

Length frequency distributions of the landings were transformed into age distributions by means of a knife-edge age slicing procedure (LFDA 5.0). The slicing was carried out on separate sexes whose distributions were then combined into a sex-combined dataset for each GSA. The growth parameters used are those summarised in Table 5.2.6.2.1. for the two GSAs.

Data sources:

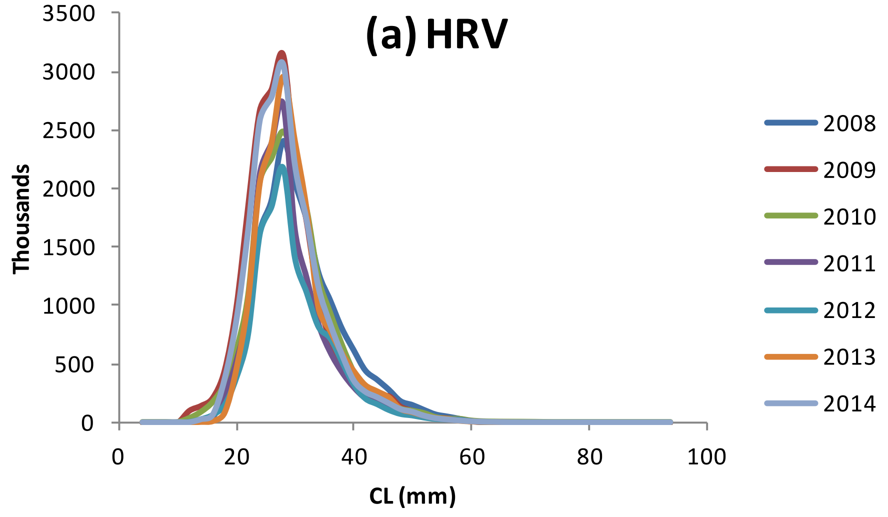
- Croatian FPO (traps) landings and landings at length were missing for years 2008 – 2012 and were thus reconstructed using DCF data from 2014 (Table 5.2.6.5.3.1; Fig. 5.2.6.5.3.1);
- Croatian OTB landings and landings at length for 2008 – 2012 were provided by the Institute of Oceanography and Fisheries (IOF), Split, Croatia (Table 5.2.6.5.3.1; Fig. 5.2.6.5.3.1). These were provided as total length and were converted into carapace length using the following equation (Froglia and Gramitto, 1988):

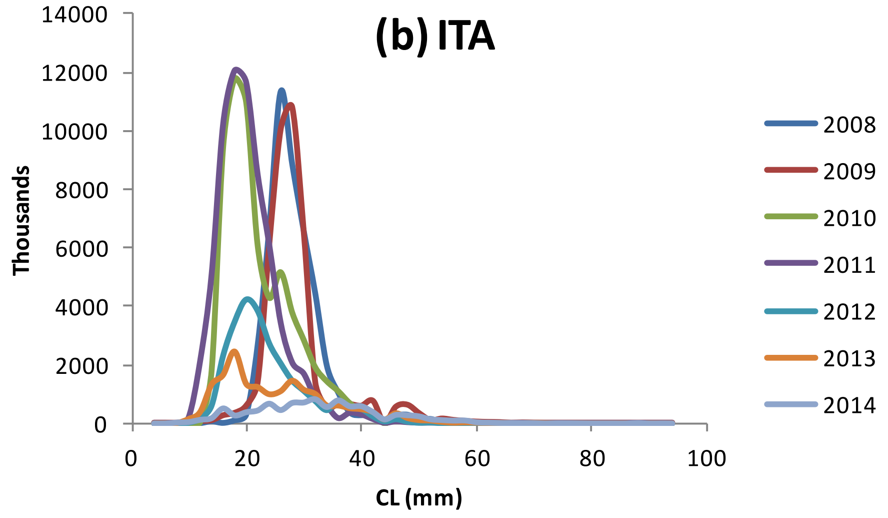
$$CL\ (mm) = 0.017275 + ((TL/10) * 0.30265)$$

- Italian OTB landings for GSA 17 came from the DCF; these were aggregated by sex (Table 5.2.6.5.3.1; Fig. 5.2.6.5.3.1). Prior to slicing, sexes were split according to the sex ratios reported in the DCF dataset;
- GSA 18 landings came from the DCF (Table 5.2.6.5.3.1; Fig. 5.2.6.5.3.1) and were already sliced, initially by sex and then merged.

Length frequency distributions (LFDs) of landings in GSA 17 (Fig. 5.2.6.5.3.2) show that whilst Croatian landings (Fig. 5.2.6.5.3.2 a) are fairly homogenous with modal sizes around 28 mm CL, Italian landings vary considerably, seemingly with two populations of animals, one with a mode around 20 mm CL and another with a mode around 30 mm CL (Fig. 5.2.6.5.3.2 b). The remarkable similarity of Croatian LFds can also be attributable to the fact that (i) some years are reconstructed and (ii) that a conversion had to be done from total length to carapace length.
These differences are likely reconducible to the two different areas where the Italian fleet operates: inside and outside of the Pomo/Jabuka pit. With a couple of exceptions (2012 and 2014) where modal size is around 24 mm CL, the LFDs of the landings from GSA 18 are variable but similar to eachother with animals whose modal size is around 28 – 30 mm CL (Fig. 5.2.6.5.3.3). The exceptions are likely due to the fact that vessels landing in GSA 18 are known to fish in GSA 17, in certain conditions pushing themselves as far as the Pomo/Jabuka pit.

Age frequency distributions highlight the problem related to the the individuals in the Pomo/Jabuka pit being smaller. Juvenile (age 0) *Nephrops* are known to mostly remain in their burrows and are thus unlikely to be caught by bottom trawl gear. This is evident in the age frequency distributions for GSA 18 (Fig. 5.2.6.5.3.5) which result in very low numbers of age 0 animals. The age frequency distributions for GSA 17 (Fig. 5.2.6.5.3.4), on the other hand, in some years indicate high numbers of age 0 individuals in landings. This is particularly true for 2010 and 2011 (and untrue for 2008 and 2009), corresponding to the phenomenon described in the paragraph above where LFDs for 2010 and 2011 were characterised by smaller individuals overall, likely coming from the Pomo/Jabuka pit. When slicing landings at length into landings at age, the application of the same average growth parameters to all LFDs from GSA 17, irrepsective of their origin (Pomo or outside Pomo), results in the misleading notion that GSA 17 has high numbers of age 0 *Nephrops* being caught in some years; these, in reality, are likely to be smaller age 1 individuals.





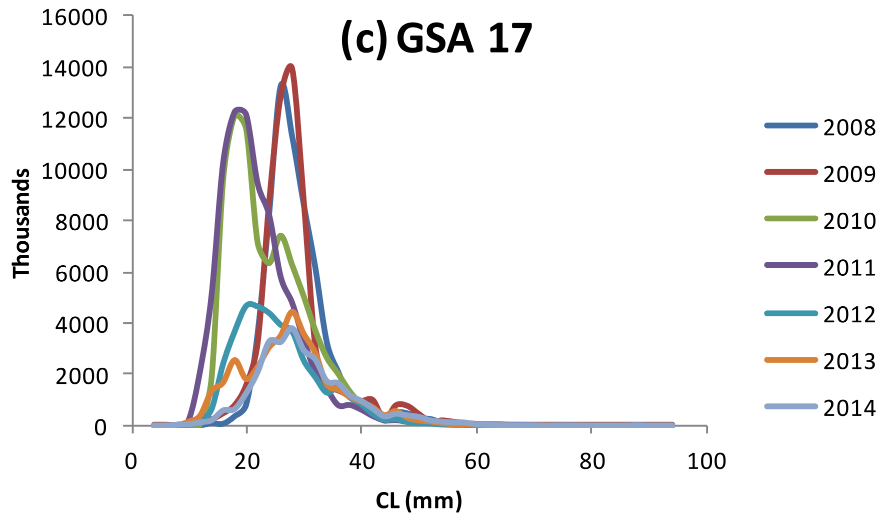


Figure 5.2.6.5.3.2. Norway lobster in GSA 17 and 18. Landings at length, all métiers together, for GSA 17: (a) Croatia (HRV), (b) Italy (ITA), (c) the whole GSA 17 (HRV + ITA) (length bins = 2 mm CL).

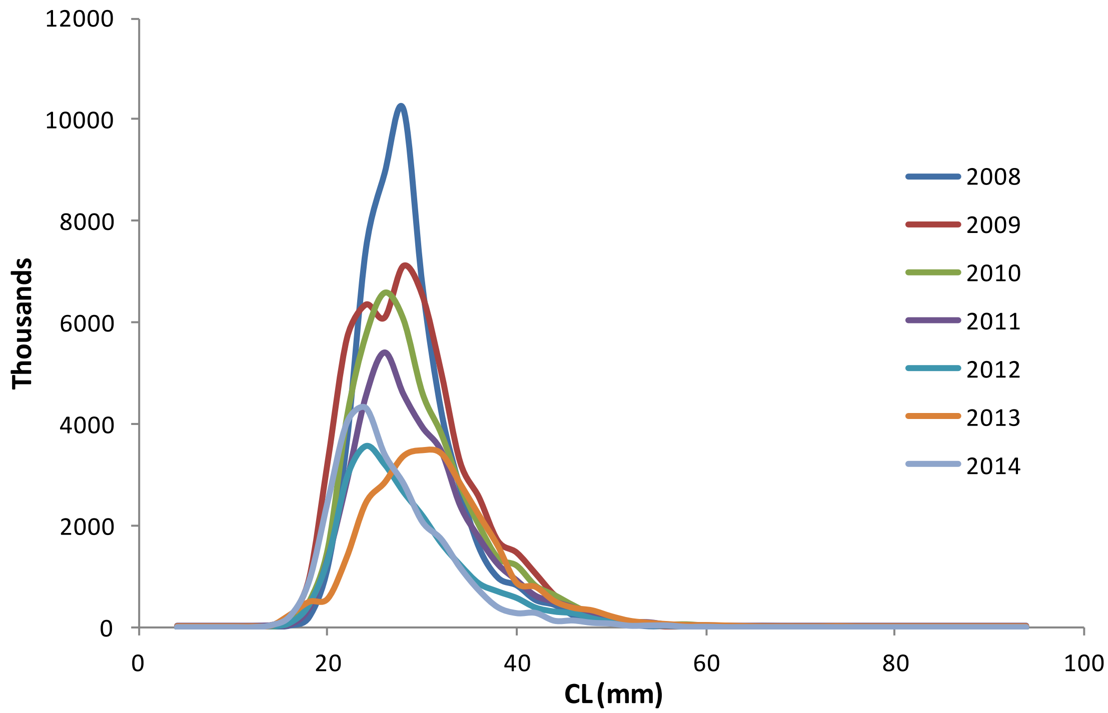


Figure 5.2.6.5.3.3. Norway lobster in GSA 17 and 18. Landings at length in GSA 18 (length bins = 2 mm CL).

Table 5.2.6.5.3.2. Norway lobster in GSA 17 and 18. Landings at age (thousands), all métiers together, for GSA 17. Note that a SOP correction had to be applied to the original numbers.

Year/Age	0	1	2	3	4	5	6	7	SOP corr. (%)
2008	527.13	53511.64	15223.54	2334.62	1010.86	327.02	86.30	47.27	49
2009	1961.74	64420.41	11049.28	2924.47	1562.75	282.04	152.09	128.20	17
2010	27694.48	60321.72	12854.14	2321.67	856.38	256.33	75.25	74.94	34
2011	37726.81	63380.48	7167.08	1413.66	385.84	122.93	43.05	36.24	31
2012	9681.25	38303.75	9128.93	2251.79	551.02	187.51	56.21	44.65	38
2013	6705.29	22963.77	8448.54	2344.25	774.33	265.90	72.14	56.17	57
2014	1787.79	19577.97	8367.36	2210.52	923.58	316.10	130.22	140.92	21

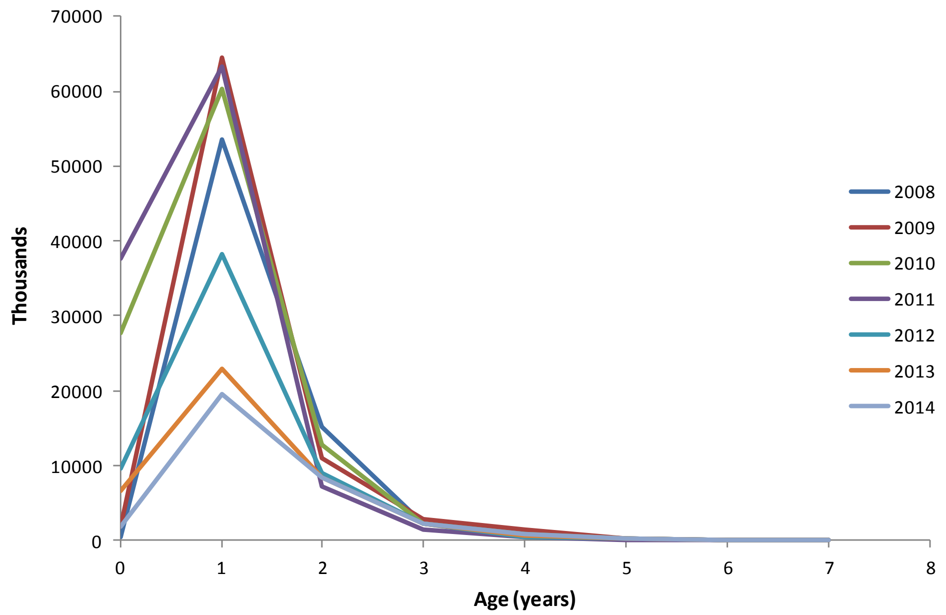


Figure 5.2.6.5.3.4. Norway lobster in GSA 17 and 18. Landings at age, all métiers together, for GSA 17.

Table 5.2.6.5.3.3. Norway lobster in GSA 17 and 18. Landings at age (thousands) for GSA 18.

Year/Age	0	1	2	3	4	5	6	7
2008	5.037	9786.607	27192.807	10420.908	2274.003	433.792	81.442	37.177
2009	148.149	14912.932	22753.113	10876.062	3125.319	722.868	92.392	68.658
2010	36.457	8782.856	20786.440	9258.378	2747.913	862.771	254.600	148.103
2011	15.558	6957.777	15836.087	8390.391	2502.064	632.390	198.540	98.189
2012	56.875	6373.567	9658.705	4639.796	1478.369	431.001	135.216	79.734
2013	80.941	4101.966	10898.350	8443.638	3079.963	925.489	292.666	183.621
2014	112.295	10186.124	10256.874	3381.971	919.263	293.444	116.131	65.866

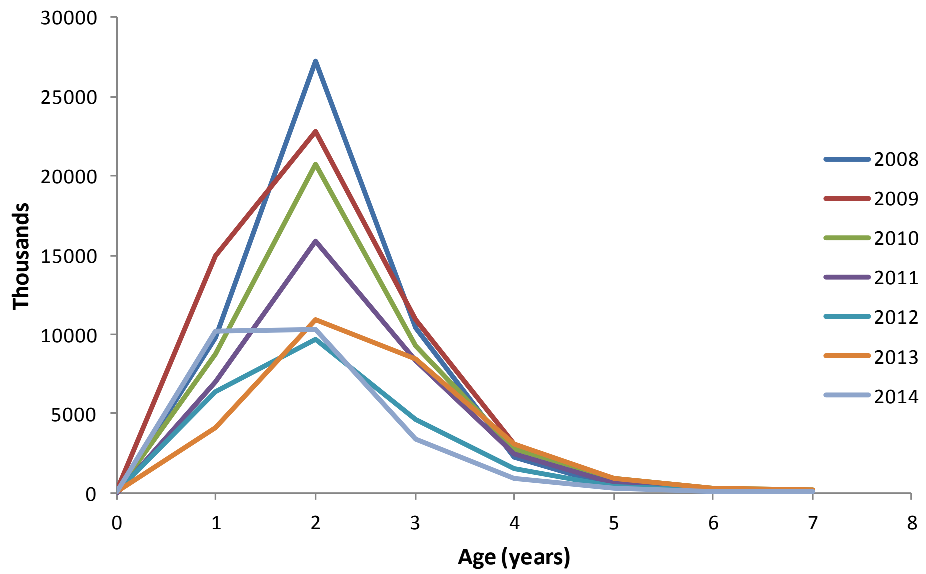


Figure 5.2.6.5.3.5. Norway lobster in GSA 17 and 18. Landings at age for GSA 18.

5.2.6.1.4 Discards

The proportion of the discards of Norway lobster from the trawl fishery (OTB) in the GSAs 17 and 18 has generally been low: with the exception of Croatia in 2013 (when discards accounted for 9% of total catch), the percentage of discards has mostly been well under 5% of total catch (Table 5.2.6.5.4.1). Considering the low amount of discards and the lack of data for GSA 17 (Italy and Croatia), it was decided not to use discard data in the present assessment.

Table 5.2.6.5.4.1. Norway lobster in GSA 17 and 18. Landings at age, all métiers together, for GSA 17.

Country	GSA	Year	Discards (tonnes)	Landings tonnes)	Percentage of total
HRV	17	2013	27.5	278.4	9.0
HRV	17	2014	15.0	325.2	4.4
ITA	17	2011	4.9	936.6	0.5
ITA	18	2009	66.8	1092.9	5.8
ITA	18	2010	6.2	1023.4	0.6
ITA	18	2011	0.8	759.2	0.1
ITA	18	2012	4.0	458.7	0.9
ITA	18	2013	2.3	833.8	0.3
ITA	18	2014	5.1	444.7	1.1

5.2.6.1.5 Fishing effort

Fishing effort for *N. norvegicus* in the Adriatic Sea (GSAs 17 and 18) has been almost equally distributed among the bottom trawls of Italy and Croatia since 2012, whereas effort from other fisheries is negligible (Fig. 5.2.6.5.5.1. Figure). Data on fishing effort before 2012 is not available for Croatia.

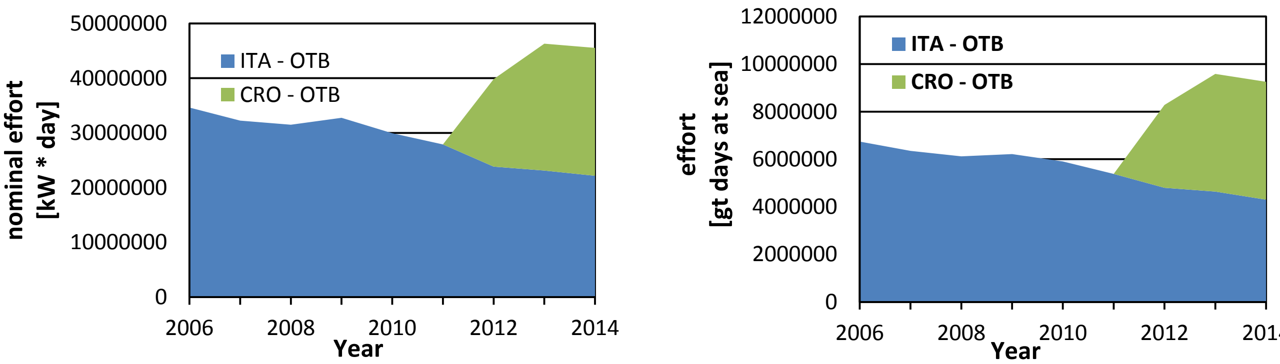


Figure 5.2.6.5.5.1. Norway lobster in GSA 17 and 18. Nominal effort in kW days on the left and effort in gt days at sea on the right for Italian and Croatian OTB fleets.

Table 5.2.6.5.5.1. Norway lobster in GSA 17 and 18. Nominal effort in kW days on the left and effort in gt days at sea on the right for Italian (ITA) and Croatian (HRV) OTB fleets.

	nominal effort [kW days]		effort [gt days at sea]	
Year	ITA - OTB	HRV - OTB	ITA - OTB	HRV - OTB

2006	34641421		6741848	
2007	32249251		6351016	
2008	31502213		6121887	
2009	32768358		6217030	
2010	29950838		5905490	
2011	27901536		5382854	
2012	23842721	15985566	4799392	3482698
2013	23125950	23186903	4640270	4946529
2014	22171347	23372460	4299825	4955927

Scientific surveys

5.2.6.1.6 Survey #1 (MEDITS)

5.2.6.1.6.1 Methods

According to the MEDITS protocol (Bertrand et al., 2002), trawl surveys were carried out yearly (May-July), applying a random stratified sampling by depth (5 strata with depth limits at: 50, 100, 200, 500 and 800 m; each haul position randomly selected in small sub-areas and maintained fixed throughout the time). Haul allocation was proportional to the stratum area. The same gear (GOC 73, by P.Y. Dremière, IFREMER-Sète), with a 20 mm stretched mesh size in the cod-end, was used throughout the time series. Detailed data on the gear characteristics, operational parameters and performance are reported in Dremière and Fiorentini (1996). Considering the small mesh size a complete retention was assumed. All the abundance data (number of fish and weight per surface unit) were standardised to square kilometre, using the swept area method.
Abundance and biomass indices were recalculated, based on the DCF data call.
Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Catches by haul were standardized to 60 minutes haul duration. Only hauls noted as valid were used, including stations with no catches (zero catches are included).

The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

$$Yst = \Sigma (Yi*Ai) / A$$

$$V(Yst) = \Sigma (Ai^2 * si^2 / ni) / A^2$$

Where:
A=total survey area
Ai=area of the i-th stratum
si=standard deviation of the i-th stratum
ni=number of valid hauls of the i-th stratum
n=number of hauls in the GSA
Yi=mean of the i-th stratum
Yst=stratified mean abundance

V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval =

Yst ± t(student distribution) * V(Yst) / n

It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution, quasi-poisson. Indeed, data may be better modeled using the idea of conditionality and the negative binomial (e.g. O'Brien et al. (2004)).

Length distributions represent an aggregation (sum) of all standardized length frequencies (subsamples raised to standardized haul abundance per hour) over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance * 100 (because of low numbers in most strata) and finally aggregated (sum) over the strata.

Given the sheer number of plots generated, these distributions are not presented in this report. To extract the standardized LFD data, the R-file provided during the meeting was used.

It should be noted that with respect to *N. norvegicus*, the MEDITS trawl surveys suffer the same problems as the trawl fishery because of the burrowing behaviour of the species. *Nephrops norvegicus* are bottom-dwellers, building complex burrows in muddy sediments, emergence from which varies with time of day, season, animal size, sex, and reproductive status, so the fishery exploits the population selectively and in a different manner according to sex (Froglia, 1972; Atkinson and Naylor, 1976; Naylor and Atkinson, 1976; Aréchiga et al., 1980; Chapman, 1980; Froglia and Gramitto, 1986; Tuck et al., 2000). Furthermore, emergence patterns follow diel and seasonal patterns. Diel patterns of peak emergence differ according to depth as follows (Bell et al., 2007):

- Shallow depths (< 30 – 40m): one peak during night time
- Intermediate depths (40 – 100m): two peaks one at dawn and one at dusk
- Deep waters (>100m): one peak during day time

The regulatory mechanisms driving these diurnal emergence patterns are yet to be pinpointed, but are believed to be entirely exogenous, from light to hydrodynamics to predation (Bell et al., 2007; Aguzzi & Sardà, 2008; Aguzzi et al. 2009a, 2008b).
Seasonal patterns are also present and most important for females who do not leave their burrows during the egg-bearing period; the emergence of both sexes is more sporadic during winter (Marrs et al., 2000; Bell et al., 2007). Juveniles tend to spend more time in their burrows.
All these factors affect the catchability of *N. norvegicus* in trawls, their absolute catches and the sex ratio of animals caught. Thus, care has to be taken when using trawl surveys to generate abundance indices: a good estimate of population density based on catchability can only be obtained if the trawl surveys are scrupulously carried out at specific times of the day/night and under the same conditions of time and season from year to year (Aguzzi & Sardà, 2008). Furthermore, the MEDITS survey is restricted to the day time; depending on the area this may not correspond to the time of maximum emergence of the species. An alternative would be to carry out surveys based on methods that are

independent of the emergence behaviour of the animal: underwater TV (UWTV) surveys counting burrow openings are the most common of these methods. Since 2009 Italy and Croatia have been carrying out a yearly underwater television (UWTV) survey covering the entire Pomo/Jabuka area using a stratified random sampling design. This survey has the aim of quantifying the density of *N. norvegicus* via an estimation of the number of burrows seen by a towed underwater camera using the same method used in the eastern Atlantic and North Sea (ICES, 2012). All details on the method and the survey are provided in Morello et al. (2007) and Martinelli et al. (2013). Burrow densities are available for 2009, 2010, 2012, 2013, 2014 and partly for 2015. These data should be accompanied by a warning regarding their status as relative or absolute. The issue here is related to the application of a mean biomass to burrow numbers to generate an overall biomass at sea: this relies on a number of assumptions such as single-occupancy, burrow detection (there is a lower limit to the size of burrows that can be identified) and the actual mean weight of individuals within the burrows (ICES, 2013). Nevertheless, if area-specific sources of bias are accounted for systematically, UWTV estimates can be considered as absolute indicators of *N. norvegicus* biomass (ICES, 2009) and are consequently used to set Harvest Control Rules in ICES areas. Unfortunately, in the Adriatic Sea this survey is not supported by national or European funds (it is funded by ISMAR – CNR Ancona and few other external sources of funding) and for this reason it is spatially restricted to the Pomo/Jabuka pit, preventing these data from being utilzable a GSA-wide assessment of *Nephrops*.

5.2.6.1.6.2 Geographical distribution

The MEDITS surveys for GSAs 17 and 18 were considered as separate tuning indices in the merged stock assessment.

5.2.6.1.6.3 Trends in abundance and biomass

Decreasing trends in abundance and biomass are evident for GSA 17, whilst those for GSA 18 appear to be more stable even if variable (Figs. 5.2.6.6.1.3.1 and 5.2.6.6.1.3.2)

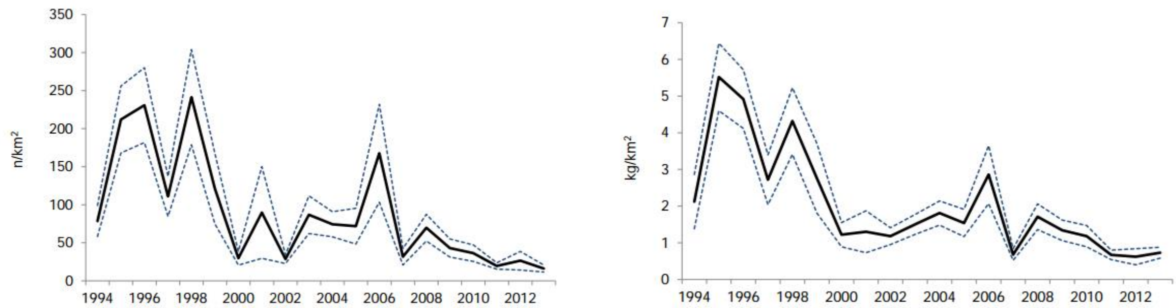


Fig. 5.2.6.6.1.3.1. Norway lobster in GSA 17 and 18. Abundance (left) and biomass (right) indices from the MEDITS survey in GSA 17 1994 – 2013.

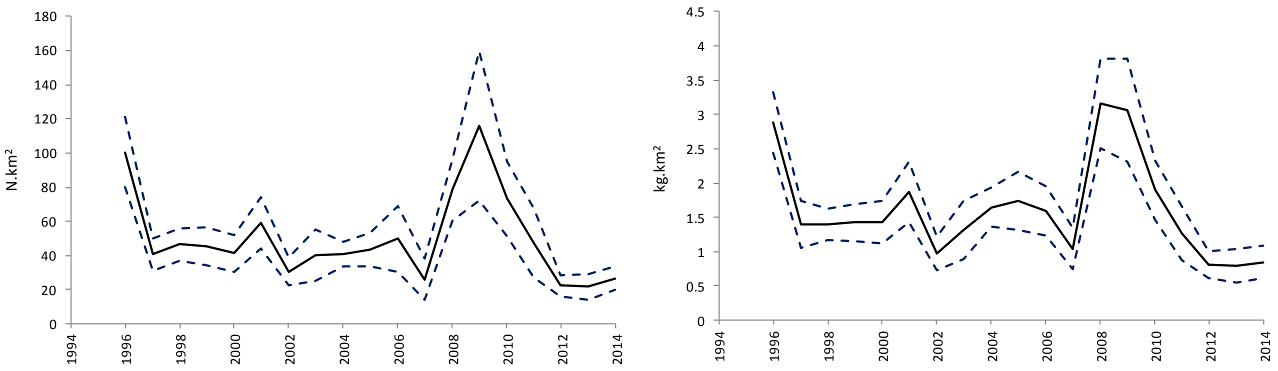


Fig. 5.2.6.6.1.3.2. Norway lobster in GSA 17 and 18. Abundance (left) and biomass (right) indices from the MEDITS survey in GSA 18 1996 – 2013.

5.2.6.1.6.4 Trends in abundance by length or age

The length frequency distributions point to an overall slightly smaller population of *Nephrops* in GSA 17 compared to GSA 18 (Figs 5.2.6.6.1.4.1 and 5.2.6.6.1.4.3). In some years, e.g. 2009, the abundance of animals is very different between the GSAs; this emphasises the uncertainty of this trawl survey with respect to this species.

GSA 17:

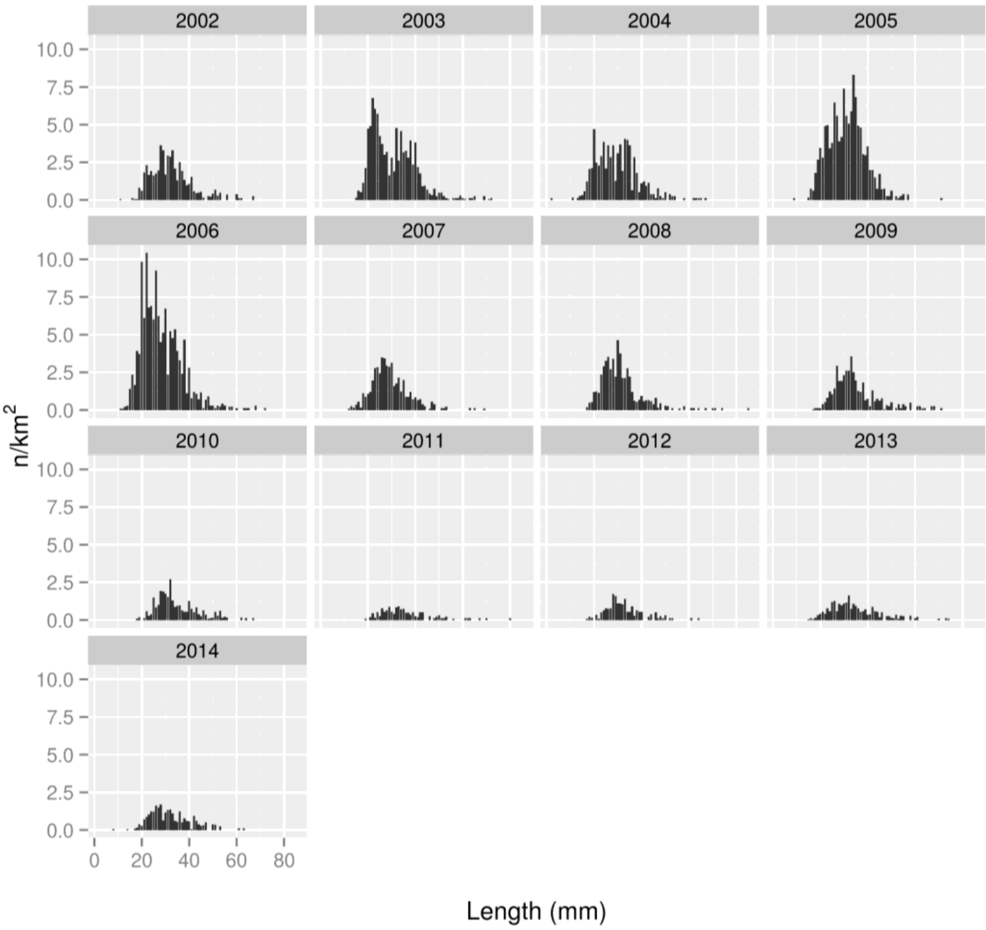


Figure 5.2.6.6.1.4.1. Norway lobster in GSA 17 and 18. Stratified abundance indices by size from MEDITS survey 2002-2014 for GSA 17 (length bins = 1 mm CL).

Table 5.2.6.6.1.4.1. Norway lobster in GSA 17 and 18. Stratified abundance indices by age from MEDITS survey 2008-2013 for GSA 17, calculated by means of a knife-edge age slicing procedure (LFDA 5.0).

Year/Age	0	1	2	3	4	5	6	7
2007	3.44	30.89	10.25	2.26	1.01	0.02	0.18	0.27
2008	1.17	33.62	11.58	3.04	1.49	0.31	0.21	0.13
2009	0.30	18.91	14.38	3.58	1.28	0.73	0.06	0.44
2010	0.25	13.55	7.70	3.05	1.14	0.33	0.60	0.77
2011	0.08	5.86	4.59	1.28	0.36	0.52	0.15	0.27
2012	0.45	10.08	5.60	0.75	0.89	0.44	0.06	0.20
2013	0.65	11.08	6.15	2.62	0.82	0.41	0.25	0.28
2014	0.67	14.18	6.22	2.35	0.87	0.44	0.30	0.25

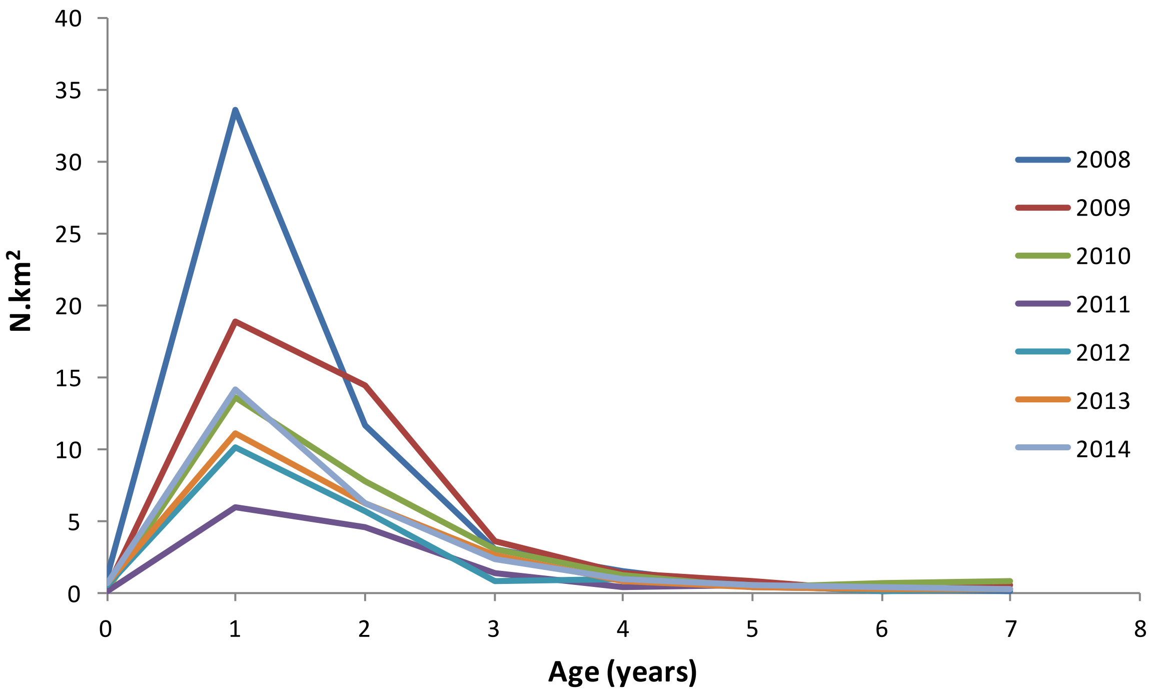


Figure 5.2.6.6.1.4.2. Norway lobster in GSA 17 and 18. Stratified abundance indices by age from MEDITS survey 2008-2014 for GSA 17.

GSA 18:

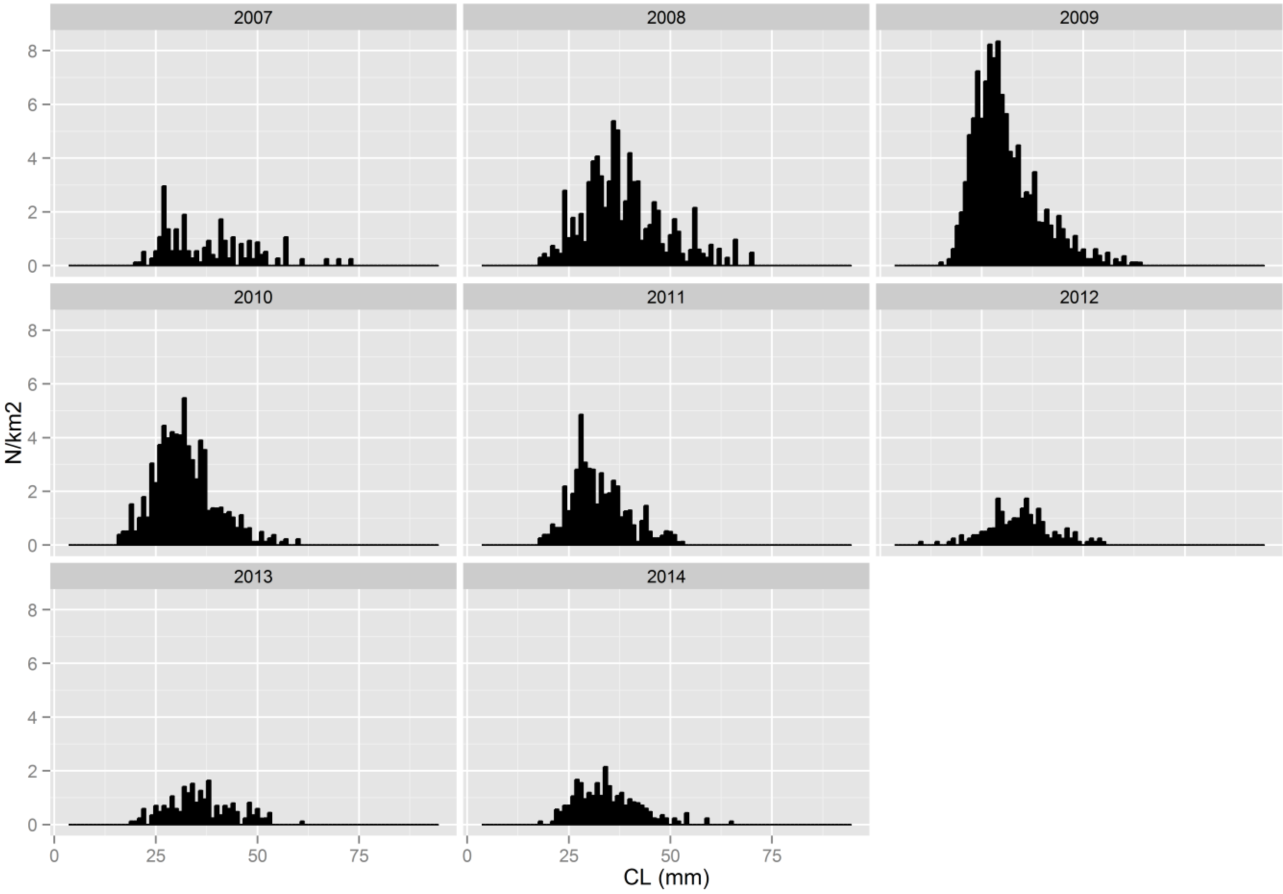


Fig. 5.2.6.6.1.4.3. Norway lobster in GSA 17 and 18. Stratified abundance indices by size from MEDITS survey 2007-2014 for GSA 18 (length bins = 1 mm CL).

Table 5.2.6.6.1.4.2. Norway lobster in GSA 17 and 18. Stratified abundance indices by age from MEDITS survey 2008-2013 for GSA 18, calculated by means of a knife-edge age slicing procedure (LFDA 5.0).

Year/Age	0	1	2	3	4	5	6	7
2008	0.00	4.82	13.20	18.44	11.74	7.89	5.26	10.54
2009	0.07	29.85	46.45	22.31	10.37	3.86	1.77	1.23
2010	0.20	11.89	27.38	20.95	9.13	2.13	1.24	0.51
2011	0.00	5.28	19.61	14.81	5.17	1.82	0.53	0.13
2012	0.39	2.06	6.17	7.56	4.20	1.25	0.72	0.08
2013	0.00	1.73	4.75	7.63	4.83	2.28	0.31	0.12

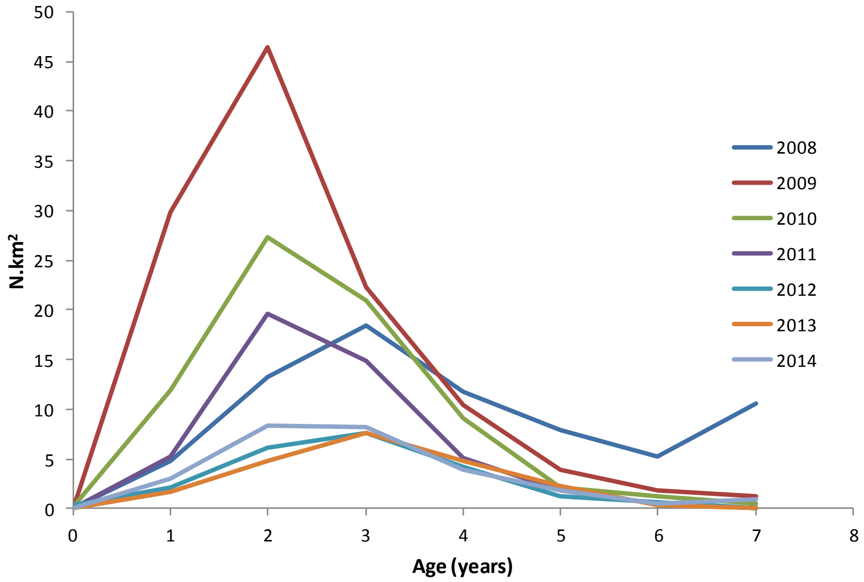


Figure 5.2.6.6.1.4.4. Norway lobster in GSA 17 and 18. Stratified abundance indices by age from MEDITS survey 2008-2014 for GSA 18.

Stock Assessment

5.2.6.1.7 Method: XSA

An Extended Survivor Analysis (XSA; Shepherd 1992, Darby and Flatman 1994) was carried out on GSAs 17 and 18 together. The shortcomings of doing so are listed in the section on data quality (section 5.2.6.9) along with the description of the alternative methodologies available to address these problems.

Virtual Population Analysis is a deterministic algorithm to sequentially calculate a matrix of stock numbers at age and a matrix of fishing mortality rates at age given a matrix of catch at age and a matrix of natural mortality at age. The algorithm back-calculates previous stock sizes using catch at age data, current-year stock size estimates, and assumptions about fishing mortality relationships between age groups. FLR libraries were employed in order to carry out an Extended Survivor Analysis (XSA; Shepherd 1992, Darby and Flatman 1994) assessment.
XSA uses catch numbers-at-age, mean weight-at-age, catches, proportion of mature individuals by age, and natural mortality by age to perform the analysis, which is tuned on survey data by age. The survey data used was the MEDITS data, in the form of standardized LFD abundance indices (N/km^2) for GSAs 17 and 18.
Norway lobster cannot be aged, so all length frequency distributions were transformed into age distributions by means of a knife-edge age slicing procedure (LFDA 5.0). The slicing was carried out on separate sexes whose distributions were then combined into a sex-combined dataset. The growth parameters used are those summarised in Table 5.2.6.2.1. for the two GSAs.
The assessment was carried out on the years 2008 to 2014.
Input data for the separate GSAs (see above) were merged using the R script developed by JRC and the assessment was run using two tuning indices one for GSA 17 and one for GSA 18.
A plus group of 7 years was used.

Sensitivity to fse, rage and qage was investigated, for a total of 30 runs:
fse: 0.5 – 2.5 by 0.5
rage: 1, 2
qage: 2, 3, 4
Shrinkage years and shrinkage ages were set to 2 owing to the short time series and short age span considered.
Owing to the problem outlined above (section 5.2.6.1.3) regarding the presence or not of age 0, which is relevant in GSA 17 alone, results are reported considering two different Fbars: one calculated on ages 1-4 (theoretically the soundest) and a second on ages 0-4 (which, given the slicing carried out is the most likely).

5.2.6.1.8 Input data

Merged input data used are summarised in tables 5.2.6.7.2.1 to 5.2.6.7.2.8.

Table 5.2.6.7.2.1. Norway lobster in GSA 17 and 18. Total landings (tonnes) from 2008 to 2014.

Year	Landings
2008	2677.2
2009	2869.2
2010	2578.4
2011	2002.5
2012	1531.4
2013	1776.7
2014	1410.9

Table 5.2.6.7.2.2. Norway lobster in GSA 17 and 18. Numbers at age (thousands) from 2008 to 2014.

Year/Age	0	1	2	3	4	5	6	7
2008	532.17	63298.245	42416.351	12755.524	3284.867	760.813	167.738	84.444
2009	2109.888	79333.341	33802.389	13800.527	4688.07	1004.904	244.48	196.856
2010	27730.941	69104.574	33640.584	11580.045	3604.292	1119.101	329.852	223.039
2011	37742.37	70338.256	23003.166	9804.051	2887.902	755.316	241.591	134.428
2012	9738.126	44677.315	18787.64	6891.582	2029.393	618.512	191.424	124.382
2013	6786.228	27065.735	19346.893	10787.887	3854.294	1191.392	364.811	239.795
2014	1900.088	29764.09	18624.234	5592.495	1842.845	609.541	246.347	206.785

Table 5.2.6.7.2.3. Norway lobster in GSA 17 and 18. Mean weight at age (kg) from 2008 to 2014.

Year/Age	0	1	2	3	4	5	6	7
2008	0.0038	0.0149	0.0235	0.0347	0.0615	0.0850	0.1058	0.1281
2009	0.0034	0.0141	0.0233	0.0381	0.0631	0.0819	0.1050	0.1365
2010	0.0037	0.0120	0.0242	0.0381	0.0635	0.0820	0.1060	0.1523
2011	0.0033	0.0110	0.0224	0.0343	0.0543	0.0763	0.0961	0.1191
2012	0.0037	0.0120	0.0255	0.0394	0.0609	0.0818	0.1003	0.1320
2013	0.0033	0.0143	0.0270	0.0403	0.0610	0.0855	0.1047	0.1450

2014	0.0033	0.0135	0.0273	0.0449	0.0698	0.0909	0.1075	0.1620

Table 5.2.6.7.2.4. Norway lobster in GSA 17 and 18. Natural mortality (y^{-1}) (weighted by catch numbers) from 2008 to 2014.

Year/Age	0	1	2	3	4	5	6	7
2008	1.2864	0.5384	0.2957	0.2173	0.2191	0.2257	0.2289	0.2278
2009	1.2493	0.5286	0.2884	0.2231	0.2238	0.1995	0.2471	0.2428
2010	1.2914	0.5464	0.3010	0.2208	0.2061	0.1905	0.1806	0.1912
2011	1.2919	0.5546	0.2849	0.2095	0.1868	0.1788	0.1722	0.1803
2012	1.2886	0.5419	0.3246	0.2461	0.2123	0.2035	0.1917	0.1949
2013	1.2849	0.5393	0.3134	0.2242	0.1993	0.1894	0.1755	0.1745
2014	1.2561	0.4837	0.3163	0.2598	0.2549	0.2413	0.2313	0.2478

Table 5.2.6.7.2.5. Norway lobster in GSA 17 and 18. Vector of proportions mature at age (fixed for all years).

Age	0	1	2	3	4	5	6	7
Mature	0.006	0.319	0.954	1	1	1	1	1

Table 5.2.6.7.2.6. Norway lobster in GSA 17 and 18. Stratified abundance indices by age from MEDITS survey 2008-2013 for GSA 17.

Year/Age	0	1	2	3	4	5	6	7
2007	3.44	30.89	10.25	2.26	1.01	0.02	0.18	0.27
2008	1.17	33.62	11.58	3.04	1.49	0.31	0.21	0.13
2009	0.30	18.91	14.38	3.58	1.28	0.73	0.06	0.44
2010	0.25	13.55	7.70	3.05	1.14	0.33	0.60	0.77
2011	0.08	5.86	4.59	1.28	0.36	0.52	0.15	0.27
2012	0.45	10.08	5.60	0.75	0.89	0.44	0.06	0.20
2013	0.65	11.08	6.15	2.62	0.82	0.41	0.25	0.28
2014	0.67	14.18	6.22	2.35	0.87	0.44	0.30	0.25

Table 5.2.6.7.2.8. Norway lobster in GSA 17 and 18. Stratified abundance indices by age from MEDITS survey 2008-2013 for GSA 18.

Year/Age	0	1	2	3	4	5	6	7
2008	0.00	4.82	13.20	18.44	11.74	7.89	5.26	10.54
2009	0.07	29.85	46.45	22.31	10.37	3.86	1.77	1.23
2010	0.20	11.89	27.38	20.95	9.13	2.13	1.24	0.51
2011	0.00	5.28	19.61	14.81	5.17	1.82	0.53	0.13
2012	0.39	2.06	6.17	7.56	4.20	1.25	0.72	0.08
2013	0.00	1.73	4.75	7.63	4.83	2.28	0.31	0.12

5.2.6.1.9 Results

GSA 17 and 18

Diagnostics:

The internal consistency of the catch age data is not too bad, although as age increases tracking of ages in the catch data decreases significantly (Fig. 5.2.6.7.3.1). The internal consistency of the sliced numbers at age of the MEDITS survey in GSA 17 is low: only ages 1 and 2, and 2 and 3 are well tracked in the catch data (Fig. 5.2.6.7.3.2). On the contrary, the internal consistency of the sliced numbers at age of the MEDITS survey in GSA 18 is good tracking of the cohorts (Fig. 5.2.6.7.3.3).

The trend in cohorts for landings and the MEDITS survey in GSA 17 shows that age 1 is the fully recruited age in most years (Figs. 5.2.6.7.3.4 and 5.2.6.7.3.5), whilst it is variable between ages 1 and 2 in the MEDITS survey for GSA 18 (Fig. 5.2.6.7.3.6).

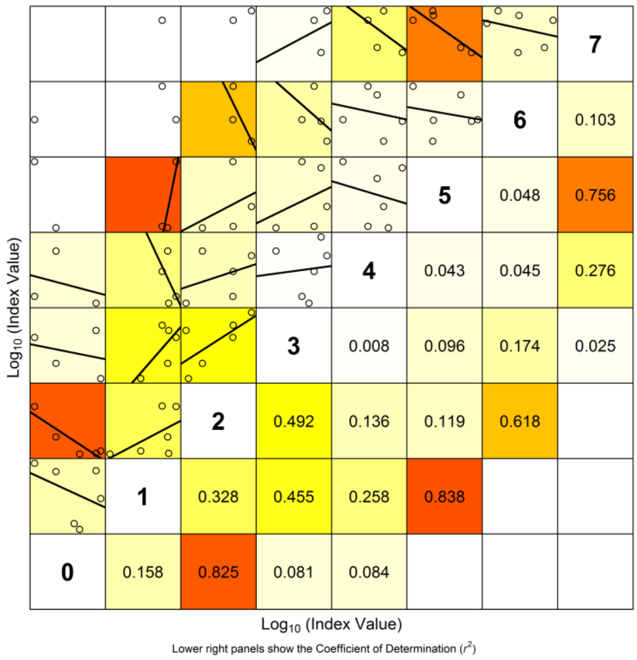


Figure 5.2.6.7.3.1. Norway lobster in GSA 17 and 18. Catch at age between-year consistency plot.

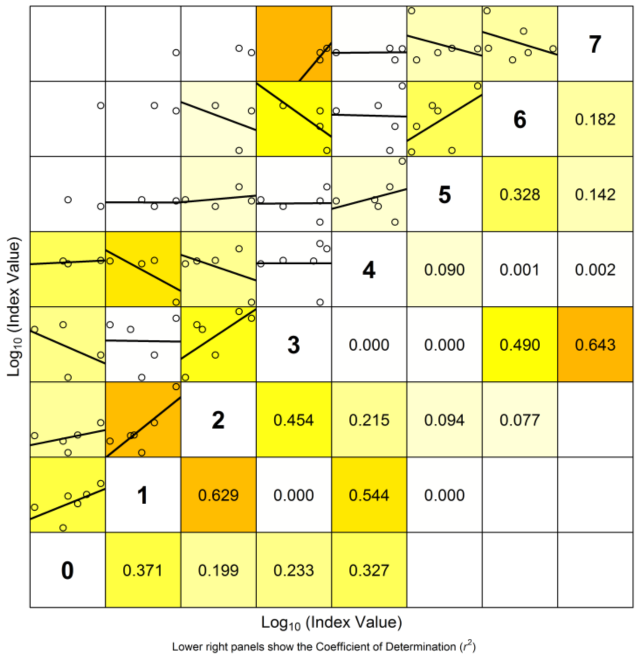


Figure 5.2.6.7.3.2. Norway lobster in GSA 17 and 18. Numbers at age between-year consistency plot for the MEDITS survey in GSA 17.

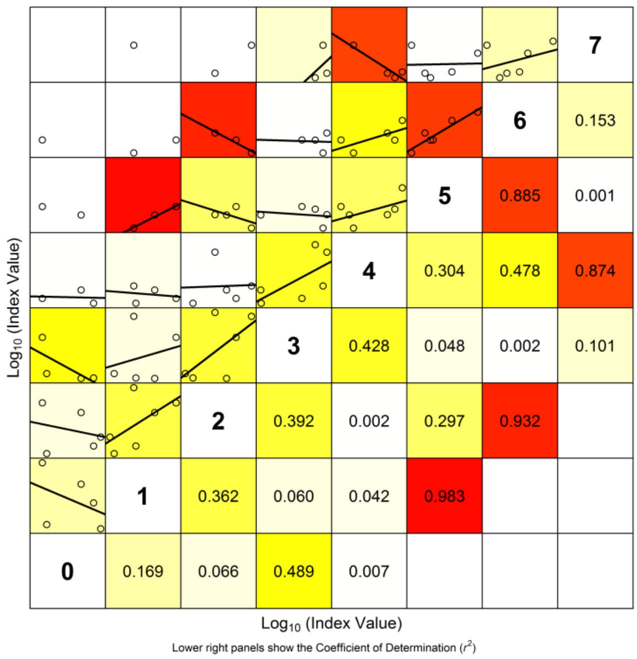


Figure 5.2.6.7.3.3. Norway lobster in GSA 17 and 18. Numbers at age between-year consistency plot for the MEDITS survey in GSA 18.

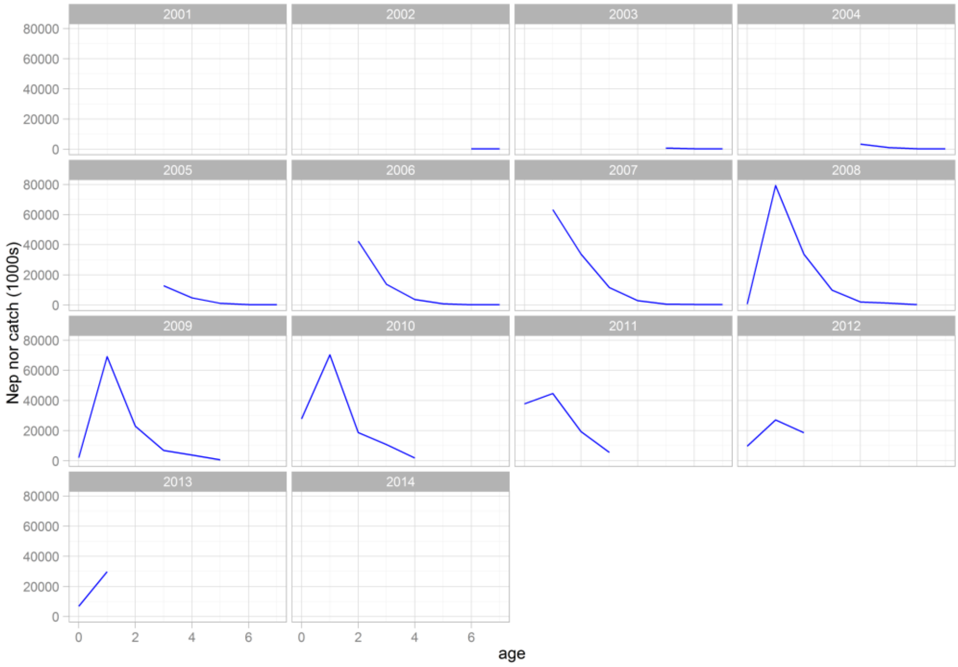


Figure 5.2.6.7.3.4. Norway lobster in GSA 17 and 18. Catch-at-age cohort plots from 2008 to 2014.

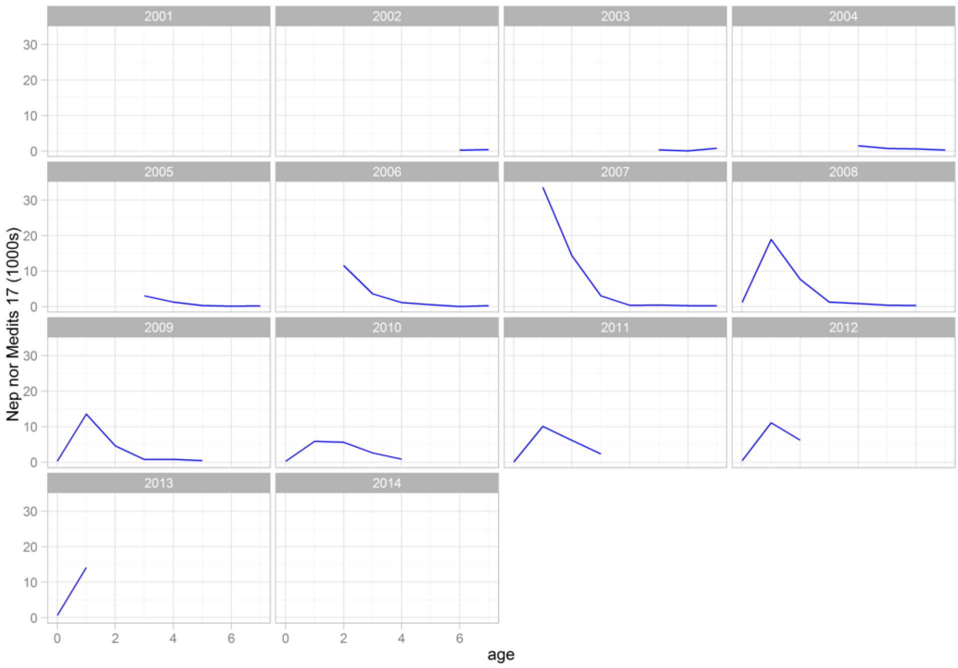


Figure 5.2.6.7.3.5. Norway lobster in GSA 17 and 18. Numbers-at-age cohort plots in the MEDITS survey in GSA 17 from 2008 to 2014.

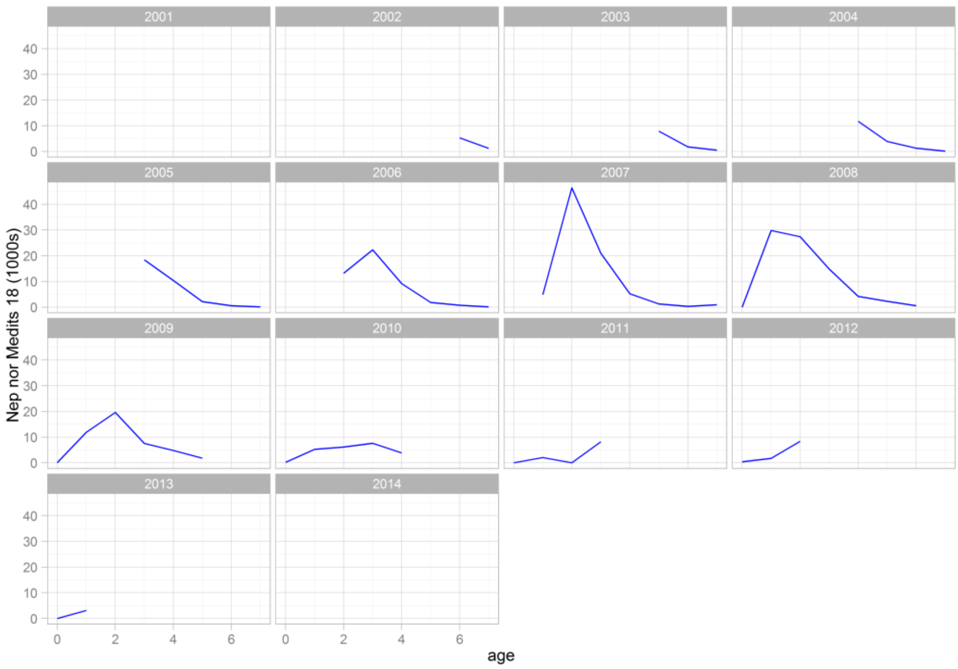


Figure 5.2.6.7.3.6. Norway lobster in GSA 17 and 18. Numbers-at-age cohort plots in the MEDITS survey in GSA 18 from 2008 to 2014.

<u>Results:</u>
High numbers of age 0 individuals are found in catches in 2010 and 2011 (Fig. 5.2.6.7.3.7) and this is coupled by a high variability in the mean weight of this age class (Fig. 5.2.6.7.3.8). This is the likely result of GSA 17 and the fact that catches were considered irrespective of their origin (Pomo vs. outside Pomo).

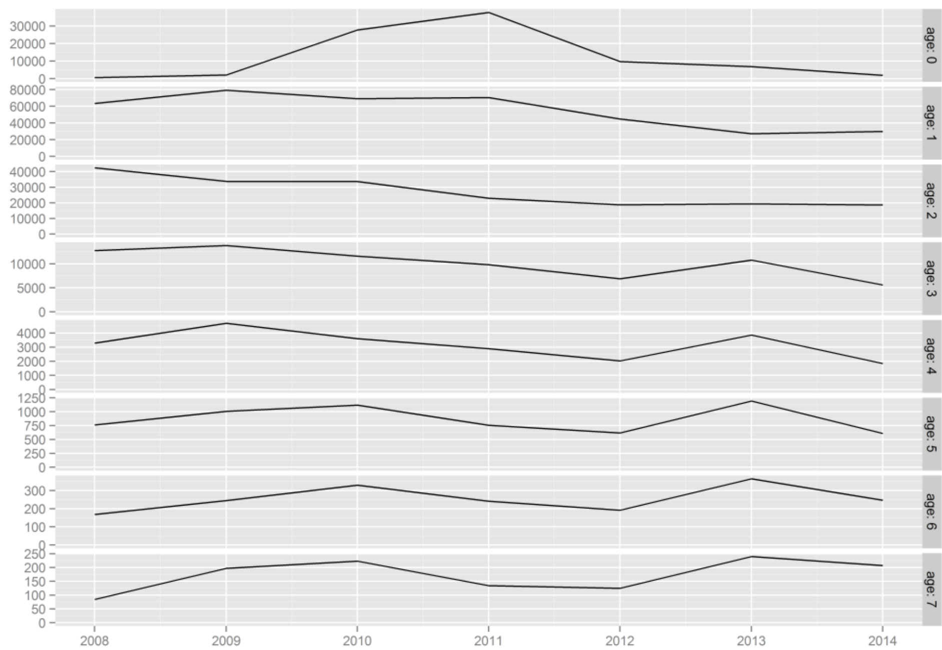


Figure 5.2.6.7.3.7. Norway lobster in GSA 17 and 18. Trends in numbers at age in the catch from 2008 to 2014.

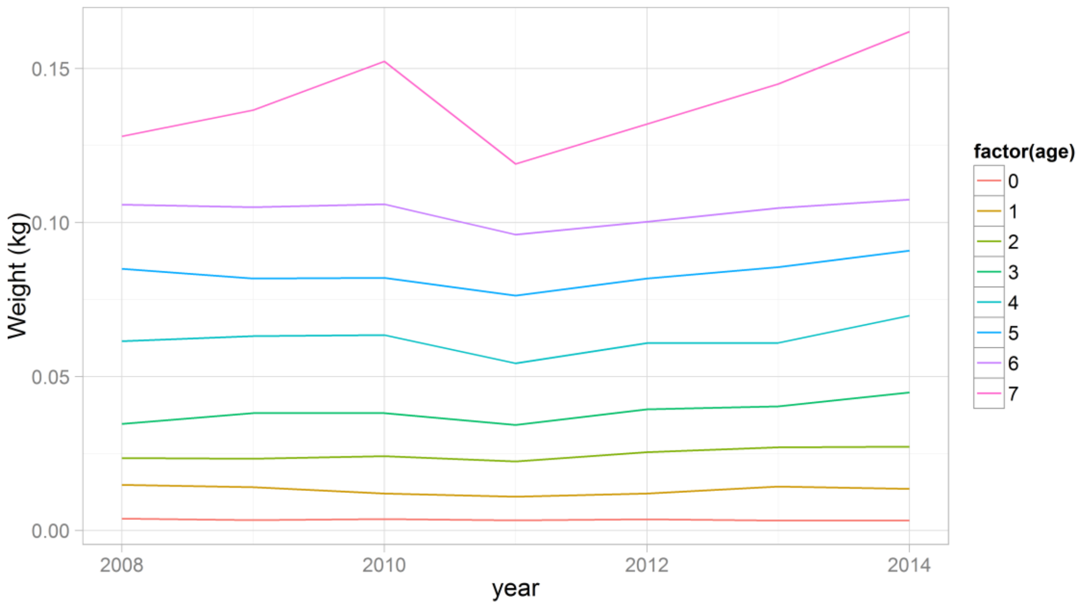


Figure 5.2.6.7.3.8. Norway lobster in GSA 17 and 18. Trends in mean weight at age in the catch of *Nephrops norvegicus* from 2008 to 2014.

Out of 30 runs with different combinations of shrinkage parameters, the best five were 15, 17, 22, 26, 27 and 28. The residuals for these five runs are compared in Table 5.2.6.7.3.1. The resulting trends in SSB, recruitment, Fbar(1-4) and Fbar(0-4) are compared in Figs Figure 5.2.6.7.3.9 to 5.2.6.7.3.12, respectively.

Table 5.2.6.7.3.1. Norway lobster in GSA 17 and 18. Residuals of the five best runs with different combinations of shrinkage parameters. Best run is indicated in red.

Run	fse	rage	qage	shk.yrs	shk.ages	Medits 17			Medits 18		
						min	max	mean abs	min	max	mean abs
15	1.5	2	3	2	2	-2.807	1.646	0.417	-0.886	1.047	0.296
17	1.5	2	4	2	2	-2.862	1.671	0.544	-0.580	1.477	0.163
23	2	2	4	2	2	-2.379	1.641	0.515	-0.577	0.791	0.159
27	2.5	2	3	2	2	-2.175	1.254	0.379	-1.279	1.646	0.296
28	2.5	2	4	2	2	-3.949	2.360	0.639	-0.733	1.066	0.232

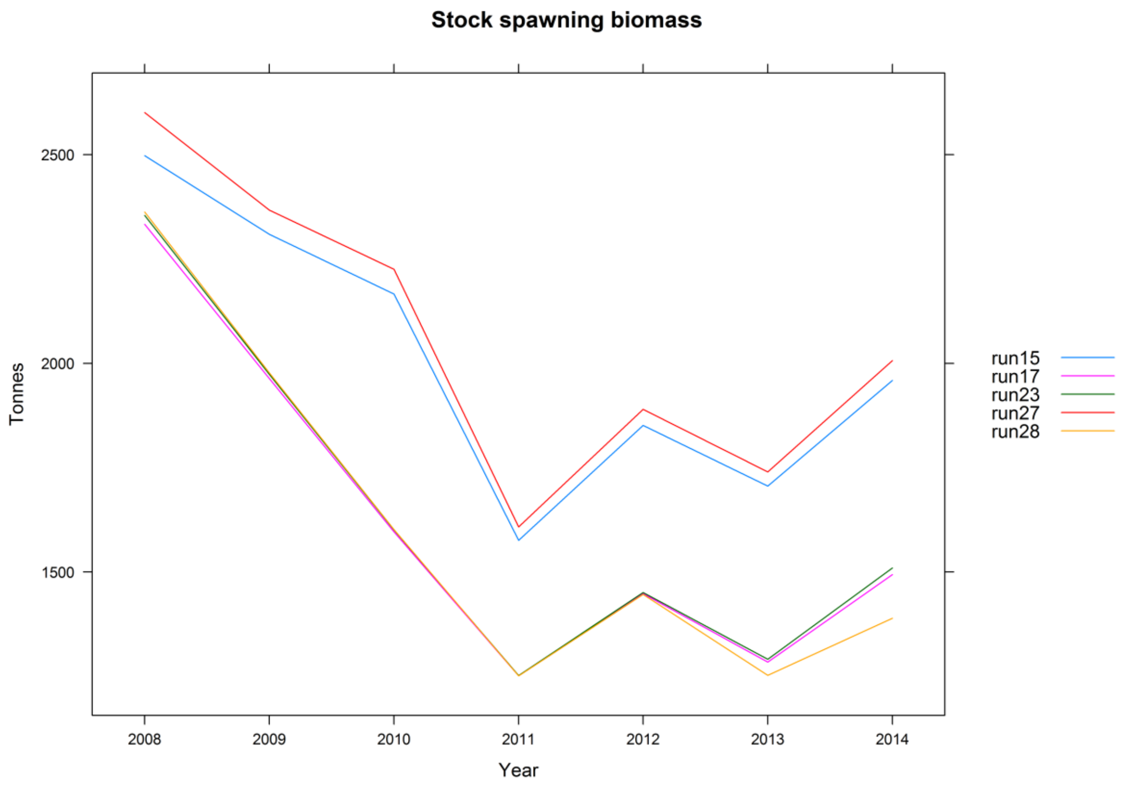


Figure 5.2.6.7.3.9. Norway lobster in GSA 17 and 18. Trends in SSB for the five best XSA runs summarised in Table 5.2.6.7.3.1.

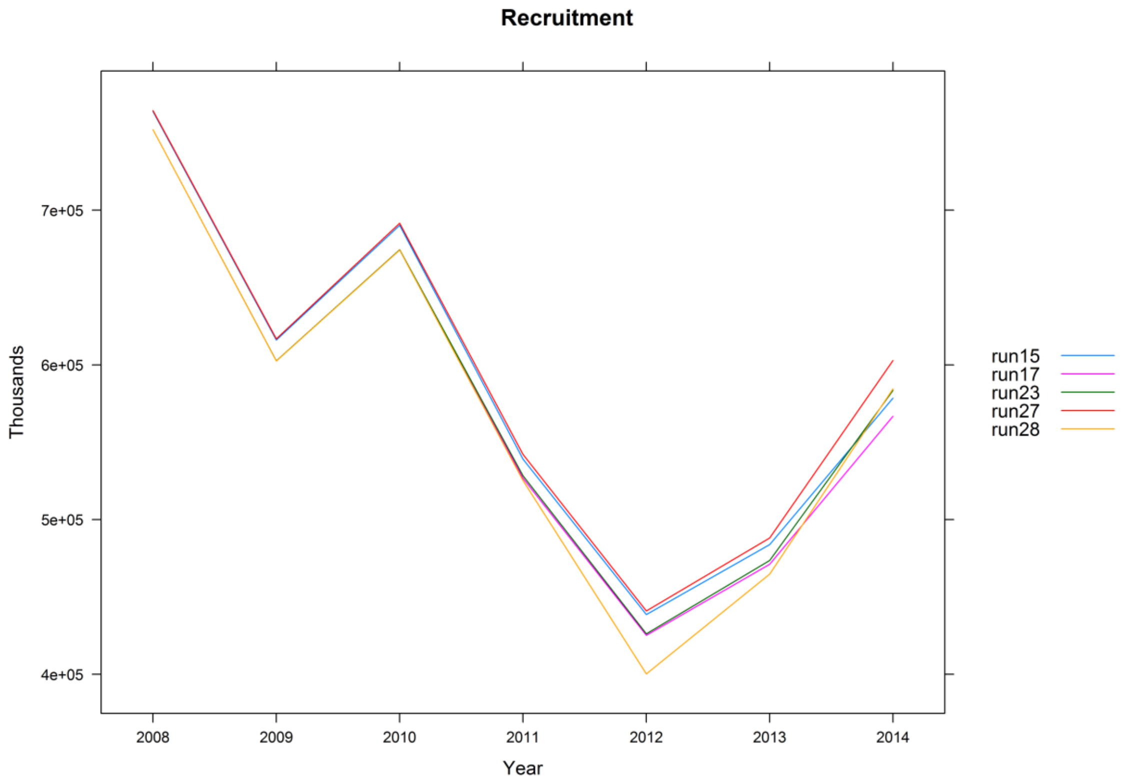


Figure 5.2.6.7.3.10. Norway lobster in GSA 17 and 18. Trends in recruitment for the five best XSA runs summarised in Table 5.2.6.7.3.1.

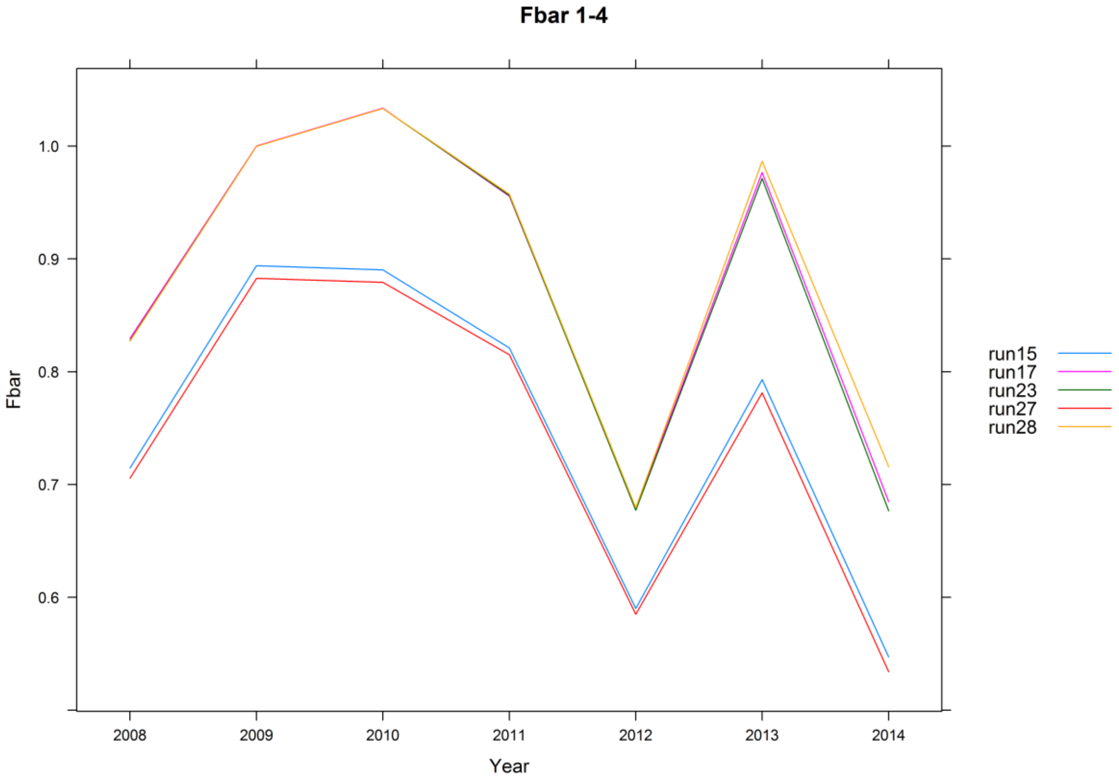


Figure 5.2.6.7.3.11. Norway lobster in GSA 17 and 18. Trends in Fbar(1-4) for the five best XSA runs summarised in Table 5.2.6.7.3.1.

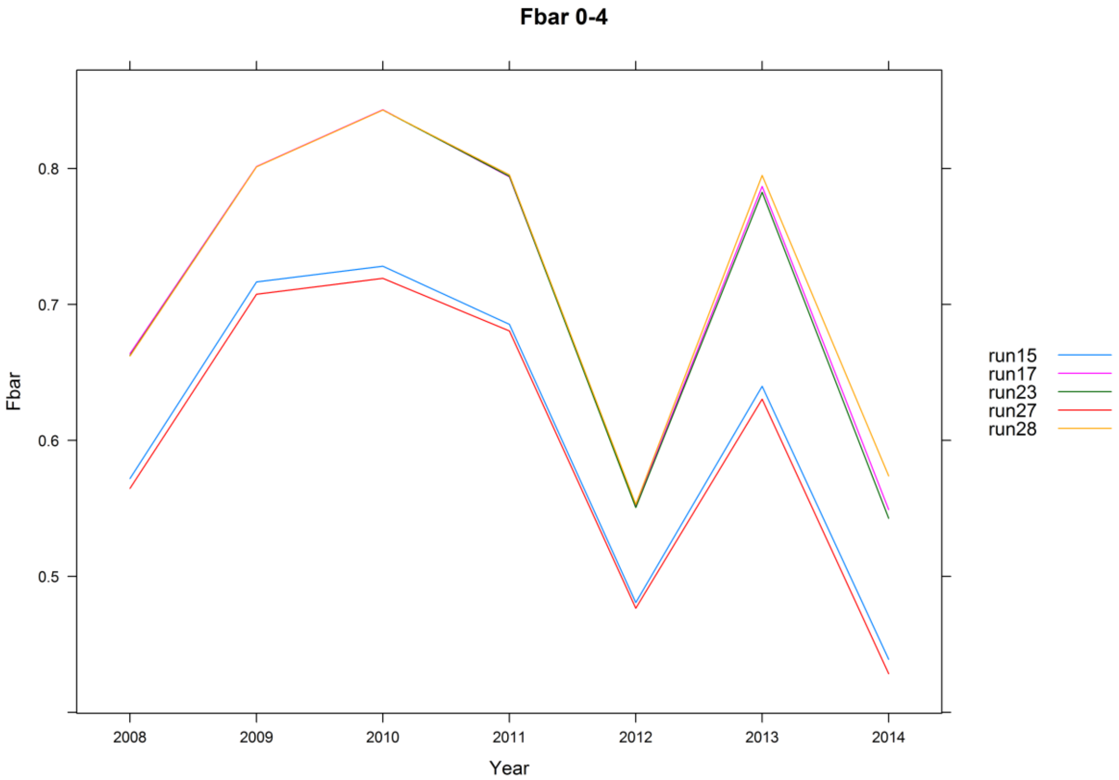


Figure 5.2.6.7.3.12. Norway lobster in GSA 17 and 18. Trends in Fbar(0-4) of the five best XSA runs summarised in Table 5.2.6.7.3.1.

Based on these results as well as the respective retrospective analyses (not shown), run 17 was chosen as the best final run:
fse: 1.5
rage: 2
qage: 4
shk.year: 2
shk.ages: 2

Results, residuals and retrospective analysis are shown in Figs 5.2.6.7.3.13 to 5.2.6.7.3.16 and Tables 5.2.6.7.3.2 to 5.2.6.7.3.4.

The main XSA outputs show a decrease in recruitment from 2008 to 2012 followed by a slight increase in the final two years; SSB decreased until 2011 and then stabilised; catches have been decreasing since 2008. When considering ages 1-4, average fishing mortality has mostly been above 0.8 y^{-1}, with the exception of 2012 and 2014 which are lower (Figs. 5.2.6.7.3.13 and 5.2.6.7.3.14). When considering ages 0-4, average fishing mortality follows the same trend as Fbar(1-4) but with lower values, all above 0.5 y^{-1} (Fig. 5.2.6.7.3.14).

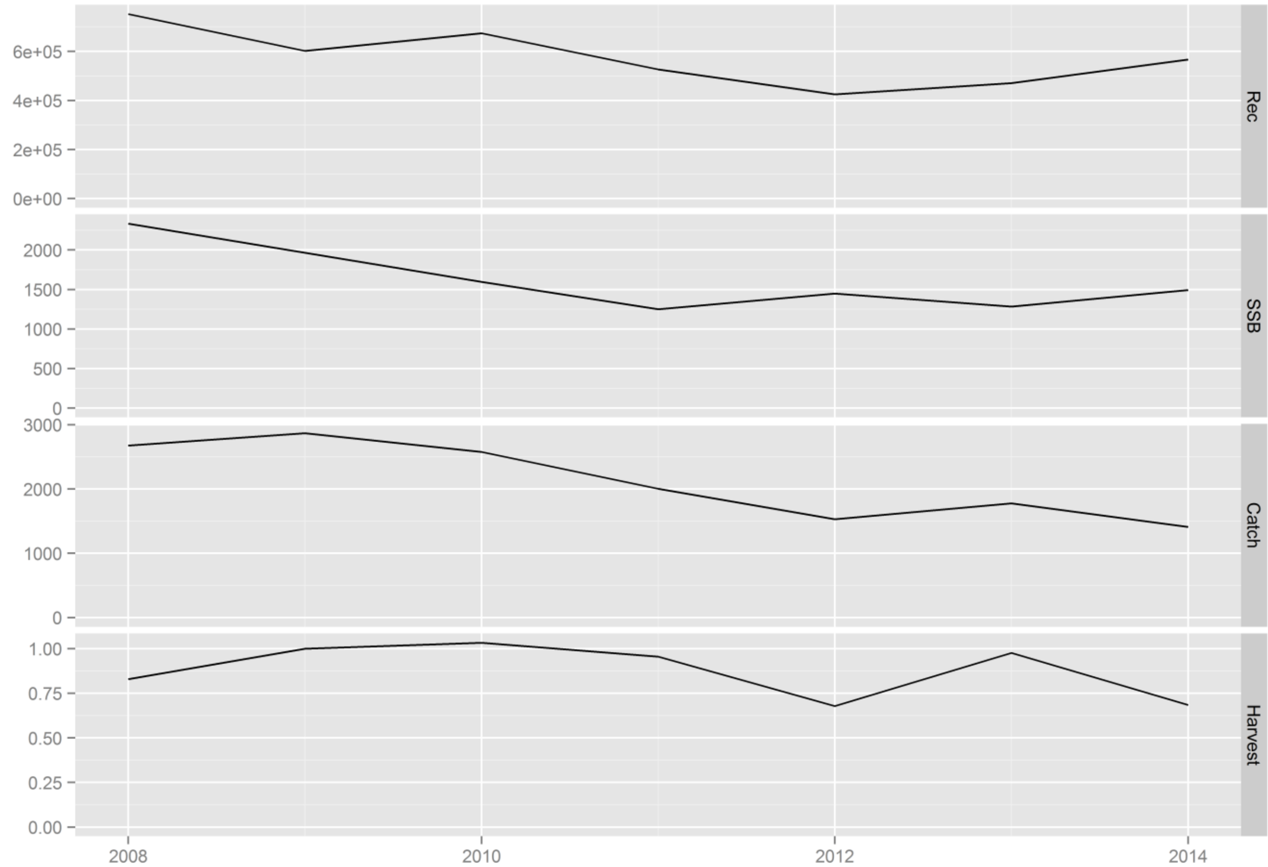


Figure 5.2.6.7.3.13. Norway lobster in GSA 17 and 18. Predicted trend in recruitment, SSB and fishing mortality (Fbar 1-4) for run 17.

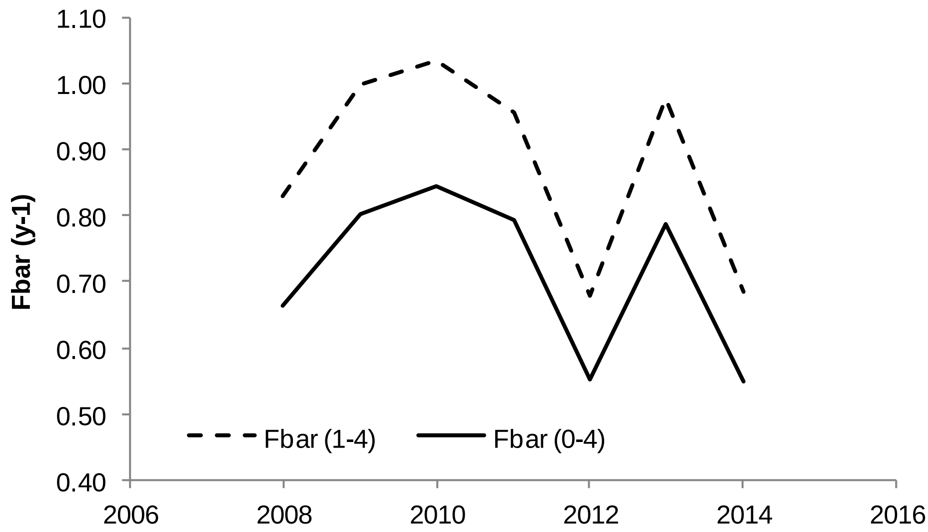


Figure 5.2.6.7.3.14. Norway lobster in GSA 17 and 18. Trends in Fbar(0-4) and Fbar(1-4) for run 17.

Table 5.2.6.7.3.2. Norway lobster in GSA 17 and 18. Fbar (1-4) and (0-4), Recruitment and SSB estimates by XSA (2008-2014) for run 17.

Year	SSB	Rec	Fbar (1-4)	Fbar (0-4)
2008	2333	752124	0.829	0.664
2009	1964	602541	1.000	0.801
2010	1596	674290	1.034	0.843
2011	1251	526798	0.956	0.794
2012	1448	425134	0.678	0.552
2013	1284	471100	0.977	0.787
2014	1494	566811	0.685	0.549

Table 5.2.6.7.3.3. Norway lobster in GSA 17 and 18. Harvest by age estimates by XSA (2008 to 2014) for run 17.

Age	2008	2009	2010	2011	2012	2013	2014
0	0.001	0.007	0.082	0.147	0.045	0.028	0.006
1	0.562	0.689	0.753	0.784	0.633	0.380	0.355
2	0.964	0.939	1.013	0.837	0.680	0.882	0.670
3	0.932	1.151	1.165	1.078	0.716	1.330	0.788
4	0.860	1.221	1.203	1.123	0.685	1.314	0.926
5	0.523	0.723	1.212	0.897	0.777	1.224	0.769
6	0.095	0.328	0.546	0.944	0.585	1.819	0.948
7	0.095	0.328	0.546	0.944	0.585	1.819	0.948

Table 5.2.6.7.3.4. Norway lobster in GSA 17 and 18. Stock numbers by age estimates by XSA (2008 to 2014) for run 17.

Age	2008	2009	2010	2011	2012	2013	2014
0	752124	602541	674290	526798	425134	471100	566811
1	192700	207503	171624	170816	124949	112076	126773
2	79506	64119	61398	46792	44795	38605	44691
3	23459	22566	18791	16499	15241	16405	11677
4	6352	7435	5710	4698	4551	5823	3467
5	2093	2158	1752	1395	1267	1855	1282
6	2067	990	858	431	476	475	452
7	1037	790	575	236	306	304	371

The residuals for the two MEDITS survey in GSA 18 appear to be rather good with no evident patterns (Figure 5.2.6.7.3.15). This for GSA 17 are less so: age 0 appears to be either overestimated or underestimated in all years and, to a lesser extent, the same appears to happen for the oler age (Figure 5.2.6.7.3.15). The MEDITS survey carried out in GSA 17 in 2014 covered 4 months: it started mid August 2014 and finished end of November 2016. Owing to the time span elapsed, the resource would have been in rather different conditions at stations sampled early in the season compared to stations sampled later on. This did not seem to particularly affect the residuals for 2014 but it may simply be due to the fact that the MEDITS survey in GSA 17 for this species is inherently variable, irrespective of whether the protocol is followed or not. Run 17 has an fse of 1.5, so the importance of the tuning datasets is rather downweighted anyways.

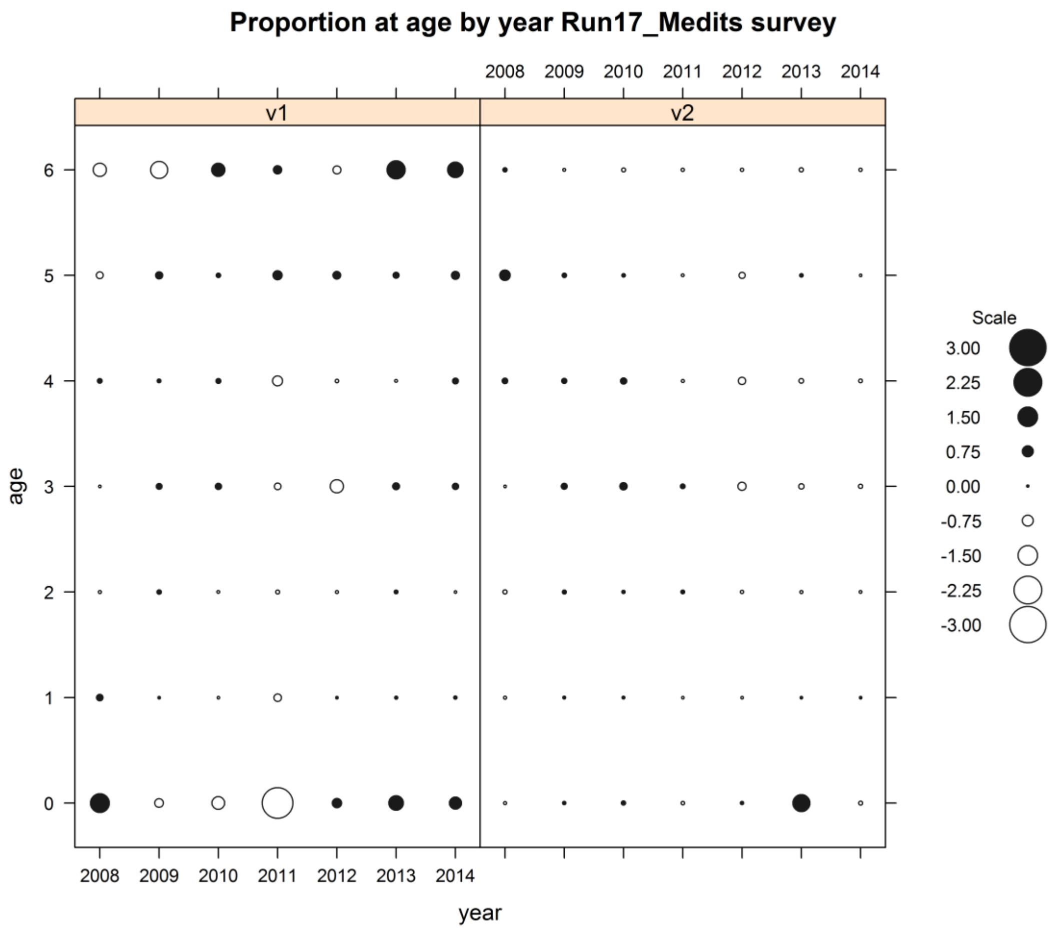


Figure 5.2.6.7.3.15. Norway lobster in GSA 17 and 18. Bubble plot of residuals for the two tuning surveys (MEDITS in GSAs 17 and 18) for run 17.

A retrospective analysis was carried out and the time series of estimates for assessments terminating in 2014, 2013 and 2012 are plotted. The retrospective series indicate moderate agreement between years in the assessment results with clear overestimation of R and F and (Fig. Figure 5.2.6.7.3.16).

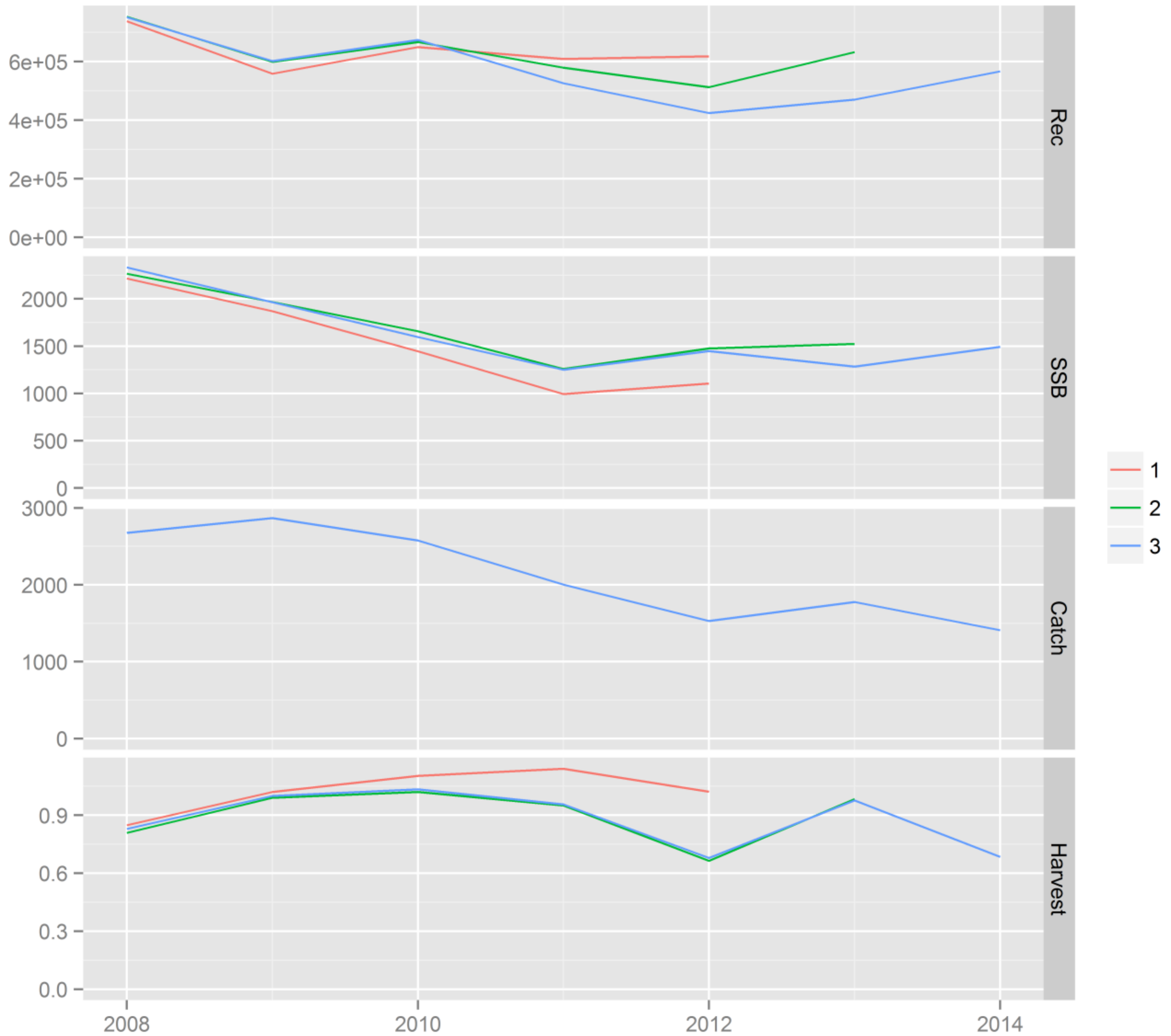


Figure 5.2.6.7.3.16. Norway lobster in GSA 17 and 18. Retrospective pattern for the main variables (recruitment, SSB and harvest) of run 17.

Reference points

5.2.6.1.10 Methods

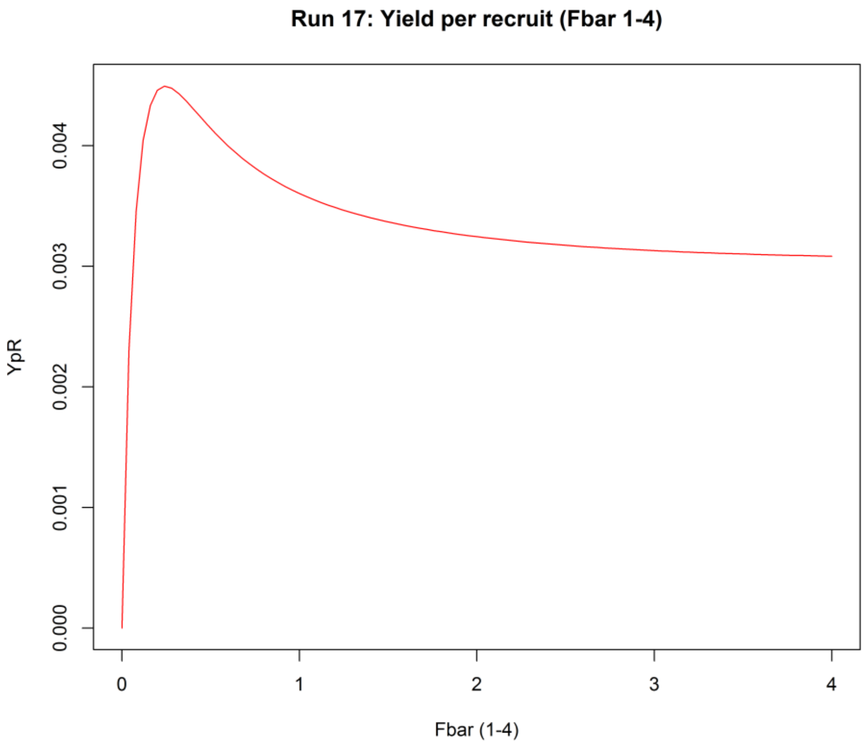
The yield per recruit analysis (YpR) was computed using the FLBRP routine on run 17. This allowed the estimation of a number of F-based Reference Points; $F_{0.1}$ was considered as a proxy of F_{MSY}.

5.2.6.1.11 Input data

Input data were the same as those used for the XSA.

5.2.6.1.12 Results

The results show that when considering ages 1-4, $F_{0.1}$ is 0.13 and when considering ages 0-4, $F_{0.1}$ is 0.11.



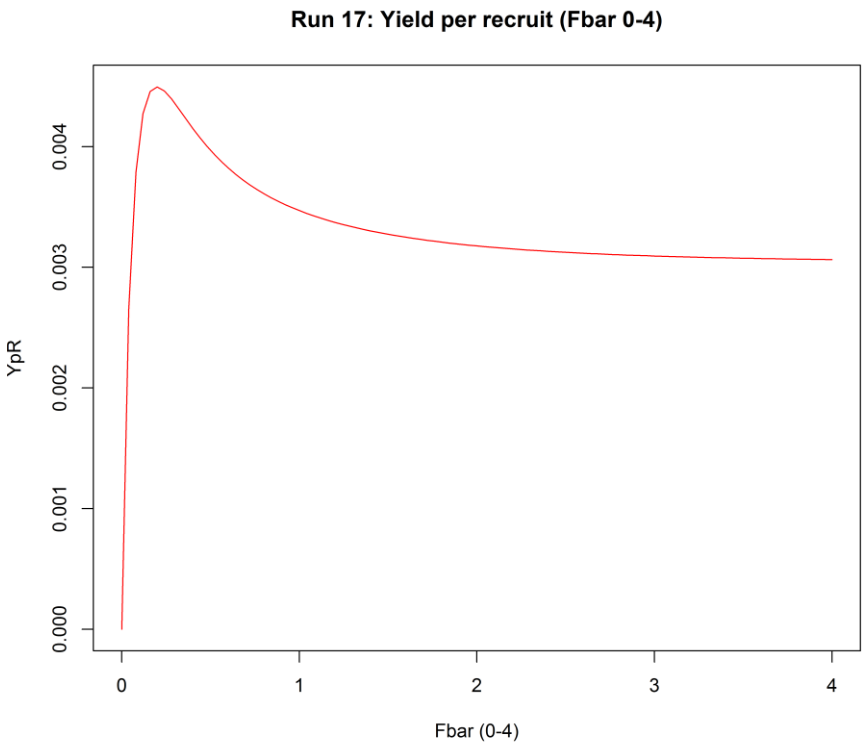


Figure 5.2.6.8.3.1. Norway lobster in GSA 17 and 18. Plots of the YPR analysis for Fbar(1-4) (top) and Fbar(0-4) (bottom).

Table 5.2.6.8.3.1. Norway lobster in GSA 17 and 18. Reference points estimated by the Yield per Recruit analysis considering two different age ranges for Fbar.

Ref. Point	Fbar 1-4	Fbar 0-4
Fmsy	0.133	0.1070
Fupper	0.187	0.1522
Flower	0.091	0.0736
Blim	1251	1251
Bpa	1752	1752
Fcurr	0.685	0.549
Bcurr	1494	1494
$F_{0.1}$	0.133	0.1070

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5.2.6.9 Data quality

In this section we would like to exhaustively summarise the shortcomings associated to this assessment, which have led the authors to deem it unacceptable for the folmulation of management advice.

The main problem lies within GSA 17 where it is known and acknowledged that *Nephrops* residing in different areas of the GSA have different growth rates. This is outlined in detail in section 8, but in essence the individuals living within the Pomo/Jabuka pit comprise a denser population of slower growing, smaller individuals compared to those residing outside the Pomo/Jabuka pit. This means that an assessment of this species in GSA 17 should consider this difference and the resource should be assessed either with two separate assessments, considering two different stock units, or using models that assume one stock unit with different growth morphs (assuming limited exchange). Furthermore, the lack of ageing methods for *Nephrops* means that growth curves for this species can only be established using indirect methods. Because of this, efforts should be made to avoid using models whose input is “at age” data generated following the conversion of length data into age data based on age slicing methods that assume Von Bertalanffy growth functions. This has been recognised for other Nephrops stocks in the world (e.g. in ICES areas of northern Europe and in New Zealand; ICES 2012a, b; Tuck and Dunn, 2012) would require the use of a length-based assessment model.

There are a number of models available at the time of writing which satisfy at least one of these conditions, although none satisfy them all simultaneously, two of them are Stock Synthesis 3 (SS3; Methot and Wetzel, 2013) and CASAL (C++ algorithmic stock assessment laboratory; Bull et al. 2012).

SS3 allows for the specification of different areas with different growth morphs and would be ideal for the problem at hand. SS3 is length-based in terms of input data, but then uses the Von Bertalanffy growth function to slice the length data into ages via an integrated MULTIFAN approach. At the time of writing, an SS3 model of the entire GSA 17 considering the two separate areas (Pomo and outside Pomo, as well as four fleets corresponding to fleets for Italy and Croatia, and two sexes) is running and converging, but the fits to the data are not very good likely because the two separate growth morphs still have to be implemented and an averaged growth function is being used.

CASAL, which is used to assess *Metanephrops challengeri* in New Zealand (Tuck and Dunn, 2012), is truly size-based, modelling growth as the process by which animals move between subsequent size classes, thus avoiding the issue of slicing length data. The downfall is that the current version of CASAL does not allow one single multi-area model with different growth morphs, but separate assessments have to be carried out for each area and then combined.

At the time of writing, two CASAL models are running and converging for GSA 17:

(i) One for the Pomo pit: this model is specified with two trawling fleets (Italy and Croatia) and makes use of UWTV survey and GRUND survey data for tuning, as well as MEDITS data. This model will benefit from more detailed Croatian landings data;
(ii) One for outside the Pomo pit: this model has a reduced area (up to the Croatian territorial waters) and only includes the Italian trawling fleet because the Croatian trawl catch outside the Pomo pit is negligible and Croatian trap data are not yet available. It makes use of GRUND survey data for tuning as well as MEDITS data.

Both CASAL models also include:

- separate sexes with different growths for each;
- two time steps to account for the fact that during the egg-bearing period females are less available to the trawls;
- total catches taken from each area: these include not only catches taken and landed in GSA 17, but also catches take in GSA 17 but landed in GSA 18

A number of reasons, not necessarily in this order, have determined the fact that neither of these models were presented in this STECF EWG 15-16:

1. The input data used are not official DCF data call data: in order to be able to assess the "sub-areas" separately, landings and survey data had to be split accordingly. Italian landings data were split using a complex methodology involving the use of Italian Vessel Monitoring System (VMS) data. This work is submitted for publication and as such not yet validated, thus not apprpriate for use in this forum, according to STECF requirements;
2. The requirement to assess GSAs 17 and 18 together: the time needed to prepare the data and do an additional SS3 or CASAL assessment for GSA 18 is greater than the week available during the STECF EWG 15-16;
3. The request made by MARE and JRC to carry out an Extended Survivor Analysis (XSA; Shepherd 1992, Darby and Flatman 1994) on GSAs 17 and 18, which limited the time available for other analysis.

For all these reasons, an XSA was carried out on GSAs 17 and 18 together. This unfortunately comes with a number of shortcomings, some theoretical and others highlighted by the assessment itself. These are:

1. It is assumed that the growth of *Nephrops* within GSA 17 is homogenous. The use of averaged growth parameters caused one very evident problem: it created a large number of age 0 individuals; animals which are not normally caught by the fishery because they tend to spend a substantial proportion of their time in their burrows. These are not really age 0 individuals but more likely age 1 individuals from the Pomo/Jabuka pit that, because of their smaller sizes, are lumped in the wrong age class because of the growth parameters used. This instils doubts in the assessment results.
2. The XSA assessment requires age data to be inputted; in the case of *Nephrops* this is obtained by slicing of length data into age data. The fact that the growth of *N. norvegicus* is sex- and stage-dependent, and the animals long-lived, means that simple selection of ages from a growth curve is not sufficient; moreover, the length distributions of *N. norvegicus*, especially commercial-sized ones, are generally not characterised by strong modes making the slicing difficult (Dobby & Hillary, 2008). Slicing is thus not capable of accounting for growth variability, resulting in smoother year class signals and derived F and biomass estimates (Dobby & Hillary, 2008). This contributes to the production of uncertain results. For this reason XSA analyses based on slicing of length data into age data have been abandoned in the northern European ICES areas in favour of the use of under water TV surveys to derive harvest ratios (Dobby and Hillary, 2008; ICES, 2004, 2012a, 2012b; Ungfors et al., 2013)
3. The only tuning dataset for this assessment is the MEDITS trawl survey which, for this species, is not ideal. Issues are both general (the survey is designed in such a manner as to not be efficient at catching *Nephrops*) and specific (the survey in GSA 17 does not necessarily strictly follow the temporal protocol in all years, a notable example being 2014). MEDITS trawl surveys suffer the same problems as the trawl fishery because of the burrowing behaviour of the species. *Nephrops norvegicus* are bottom-dwellers, building complex burrows in muddy sediments, emergence from which varies with time of day, season, animal size, sex, and reproductive status, so the fishery exploits the population selectively and in a different manner according to sex. Furthermore, emergence patterns follow diel and seasonal patterns. All these factors affect the catchability of *N. norvegicus* in trawls, their absolute catches and

the sex ratio of animals caught. Thus, care has to be taken when using trawl surveys to generate abundance indices: according to some authors, a good estimate of population density based on catchability can only be obtained if the trawl surveys are scrupulously carried out at specific times of the day/night and under the same conditions of time and season from year to year. Furthermore, the MEDITS survey is restricted to the day time; depending on the area this may not correspond to the time of maximum emergence of the species. An alternative would be to carry out surveys based on methods that are independent of the emergence behaviour of the animal: underwater TV (UWTV) surveys counting burrow openings are the most common of these methods. This methodology too comes with a number of shortcomings and is based on several assumptions. Nevertheless, the management of *Nephrops* in northern European ICES areas is based on these (ICES, 2012b). An UWTV survey is available in the Adriatic Sea, but it is not supported by national or European funds (it is funded by ISMAR – CNR Ancona and few other external sources of funding) and for this reason it is spatially restricted to the Pomo/Jabuka pit, preventing these data from being utilizable a GSA-wide assessment of *Nephrops*. It must be pointed out that we do not deem this survey useless, but, on top of the issues outlined in the first two point, it contributes to making the situation even more uncertain.

4. The different availability of males and females to trawling gear in different times of the year is not accounted for.

To yield truly informative results, an assessment of *Nephrops* should account for all these points; the fact this one doesn't, induces us to be skeptical of the results obtained and contrary to it being accepted and used to give management advice. For this reason the majority of the partecipants assessment considered the assessment not accepted and not valid for providing advice and carry out short term predictions based on the results. Nevertheless, EWG 15-16 did not reach consensus, although the majority of the partecipants was of the opinion that the assessment should not be accepted. For this reason, the opinion expressed by some of the partecipants is reported below.

On the reasons why the Nephrops XSA assessment be accepted by EWG 15-16

The presence of a subpopulation in Pomo is a hypothesis only supported by scientific evidence (different growth curves) dating before 1994 and mostly in the 1980's and based on different methods and sampling. In particular the sampling used by Froglia and Gramitto (1988), have two problems, the first thatitcovered a historical period with recurrent bottom anoxic events, which could have affected growth rates differently between different areas of the Adriatic Sea, a point also acknowledged by the authors. The second, Froglia and Gramitto (1988 compared growth rates and maturity from a small part of Pomo with those in a fishing ground off Ancona and thus the sampling did not cover the entire GSA 17. Thus assuming that the Ancona growth rates are valid for the entire GSA 17 is a very strong assumption made on top of the methodological issues with sampling and age determination.

There is no genetic evidence supporting a Nephrops subpopulation in Pomo. ADRIAMED classifies it as a panmitic stock in the Adriatic. The EU STOCKMED (http://ec.europa.eu/fisheries/documentation/studies/stockmed/stockmed-1_en.pdf) concluded that stock unit for Nephrops is GSA 17-18-19-20. Work presented in this EWG shows that there are landings from 17 in 18 and vice versa, which supports the joint assessment of 17-18.

It is been argued that MEDITS is not a reliable tuning index, but based on the internal consistency between the cohorts it does well and the XSA residuals are very acceptable. Therefore, this assessment is along the lines of other Nephrops assessments that have been accepted in the past. For example, GSA 18 (EWG 14-14, XSA), GSA 9 (EWG 14-14, XSA), GSA 5 (EWG 12-11, XSA) and GSA 15-16 (EWG 13-11, a4a).

On the use of XSA, ICES WKNEPH REPORT 2013 (http://www.ices.dk/sites/pub/Publication%20Reports/Expert%20Group%20Report/acom/2013/WKNEPH%202013/wkneph_2013.pdf), states the following:

"*In the past, it was standard practice to use a suite of indicators for Nephrops stocks. For many stocks age-based assessment methods (typically XSA) were carried out after converting lengths to ages by slicing, and tuning with commercial LPUE information. Such methods, although no longer recommended as a standard may become relevant if the UWTV surveys break down. Having a time-series of catches by length, one may also consider length based analytic assessments, using for example survey or lpue data for tuning.*"

While using XSA is not recommended as a standard by ICES, it is considered acceptable by ICES when UWTV surveys are absent, which is the exact case for the entire GSA 17, or GSA 17-18, or for the Mediterranean in general. If the EWG agrees that an age based method like XSA and MEDITS are not usable for Nephrops, and arguably for Squilla, and that Underwater Camera Surveys are the only reliable way of counting Nephrops, STECF EWG's should stop assessing any of these stocks until UWTV time series of at least a cohort (minimum 10 years) are available.

Having more advanced models would have been welcome, as long as they use official DCF data rather than raw data expandend by the experts with VMS data. However, during the EWG no results from length based methods were presented, which hampered the possibility of comparing model outputs and bringing some evidence to generic arguments in favor of these models.

Finally, addressing a TOR requesting the assessment of Nephrops in GSA 17-18 implies doing the best possible stock assessment with existing data expertise and models. This is what the XSA assessment does, the model fits well and as such it should be accepted. There are of course some caveats and assumptions related to the XSA approach, and these should have been spelled out clearly as it is the case in the current version of the EWG 15-16 report but without being a reason for rejecting the assessment. Proposing different and much more complicated modelling frameworks is very interesting, but for the time being, these clearly belong to exploratory research. In any case the fact that there are more advanced and possibly better models, should not be a reason to not accept the current assessment, especially since this one is the only one addressing the TORs and the only one running.

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On the reasons why the *Nephrops* XSA assessment should have been accepted as indicative of trends only

The stock assessors of *Nephrops* in GSAs 17 and 18 listed a series of shortcomings that might affect the reliability of the stock assessment of *Nephrops* in GSAs 17 and 18 carried out at EWG 15-16. Although we acknowledge that some aspects linked to the biology and ecology of the species and several modelling issues would deserve consideration by the group in the future, we think the assessment carried out at the EWG 15-16 represents the best science available to perform a combined assessment in GSAs 17 and 18 using DCF data.

The expert pointed out that one of the main shortcoming is about the fact that the subpopulation in the Pomo Pit should be considered separately owing to its different growth rates. The scientific evidence supporting the heterogeneity in growth in GSA 17 is based on a study by Froglia and Gramitto (1988), who estimated different growth parameters from LFDs of Nephrops collected in two areas in the Adriatic Sea: the western Pomo Pit (thus not the entire Pomo Pit) and a muddy ground off Ancona. The different growth rates reflect itself in the high proportion of age-0 individuals in the catch numbers-at-age matrix in GSA 17 (these should be age-1 individuals from the Pomo Pit that are lumped in the wrong age class because of the averaged growth parameters used for the slicing). While not questioning the methods and results of the study, we believe that assuming growth in GSA 17 is not homogeneous because of the different growth patterns in two rather small areas is a strong assumption.

Moreover, recent genetics studies revealed a single stock unit in the Adriatic Sea (Guarniero et al., 2004; Fiorentino et al., 2015).

In our opinion, the model might have benefited from applying a single set of growth parameters to the whole GSA 17, for example those estimated inside the Pomo Pit, since the 60% of landings come from the Pomo Pit, or borrowing the parameters from GSA 18. In fact, although the LFDs of commercial catches from GSA 17 and 18 are rather similar (see Fig. 5.2.6.5.3.2 and 5.2.6.5.3.3 in the report; only GSA 17 LFDs in 2010 and 2011 differ from the rest), age-0 individuals are negligible in GSA 18. MEDITS surveys data confirm the similarity in terms of size structure between GSA 17 and 18. Although we might acknowledge that trawl surveys (and trawling, in general) are not ideal to sample this species, the information provided by MEDITS surveys in GSA 17 is rather consistent along the time series, and coherent to that observed in GSA 18 in terms of both size distributions and abundance (see Figures 5.2.6.6.1.4.1 and 5.2.6.6.1.4.3 in the report).

In the light of the homogeneity in size structure, it is not clear why it is believed using a single set of growth parameters may hamper the reliability of the assessment.

Anyway, we recognize these issues deserve deeper discussion and more robust scientific evidence. Stock assessment models (i.e. SS3 and CASAL) coping with some of those caveats (e.g. ageing problems, different growth patterns, etc.) do exist, but are currently built for GSA 17 only, although work is in progress to include also GSA 18 in these models. Therefore, while supporting the implementation and use of SS3 and CASAL, we assume that the best science that the group can produce on *Nephrops* assessment in GSAs 17 and 18 still relies at the moment upon age-based assessment models such as XSA. By the way, the diagnostics and outputs of the XSA model run at the EWG 15-16 on *Nephrops* stock in GSAs 17 and 18 are reasonably acceptable. The MEDITS survey behaved well as tuning information: the internal consistency of the survey is acceptable and the residuals of the XSA model are moderate. In addition, the results of the assessment are coherent with those obtained by the assessment of Nephrops in GSA 18 (see EWG 14-19 report).

In the light of all these considerations, and acknowledging the complexity of some of the caveats pointed out by the stock assessors which are experts on *Nephrops* population dynamics in the Adriatic Sea, we deem that this assessment should have been accepted only as indicative of trends.

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5.2.7 STOCK ASSESSMENT OF SPOT-TAIL MANTIS SHRIMP IN GSA 17

Stock Identification

The spot-tail mantis shrimp (*Squilla mantis)* is widespread in the Eastern Atlantic, from the Iberian peninsula to Angola, including the Mediterranean Sea, but is absent from the Black Sea. It occupies the continental shelf to the maximum recorded depth of 247 m (Manning, 1997), but it usually digs burrows on soft bottoms to a depth of 100 m.

The highest densities of mantis shrimp in the Adriatic Sea are usually found on bottoms characterised by fine sand or sandy mud at depths of less than 50 m (Froglia *et al*., 1996). The species is more frequent in the Western side of the basin while it is quite rare in the Eastern side where the sediment features are not as suitable for their borrowing behaviour (Scarcella, pers. comm.). The burrows of *S. mantis* are commonly U-shaped, large and distinctive with two circular openings, one bigger than the other, that sometimes are more than a metre apart (Atkinson *et al*., 1997).

Unfortunately, genetic studies to support the identification of different stocks in the Mediterranean are missing. However, considering its territorial behaviour, it is reasonable to assume that the population inhabiting the Adriatic Sea is divided in 2 sub-populations characterized by a low rate of mixing and the sub-populations distributions loosely align with the two Adriatic GSAs (GFCM-WGSADS, 2012).

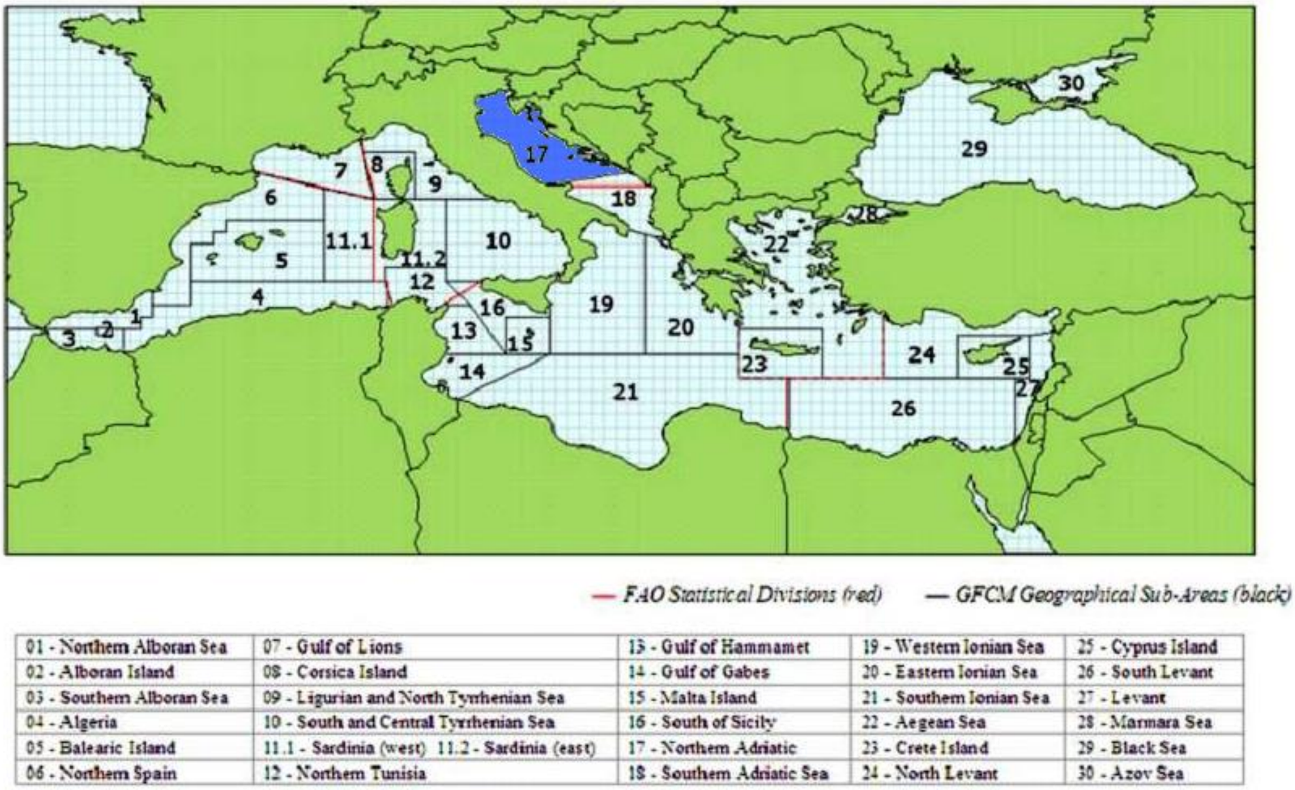


Fig. 5.2.7.1.1. Geographical localization of GSA 17.

Growth

Froglia *et al*. (1996) used an indirect method to study the growth of Spot-tail mantis shrimp in GSA 17. The length frequency distributions for males and females recorded during experimental trawls carried out in the central area of the GSA 17 in 1994 and 1995 (Froglia *et al*., 1996) showed similar size ranges for both sexes. The largest specimens were collected in September 1994 (39 mm CL for males and females) and the smallest specimens were observed in November 1994 (5 mm CL for males and females). The last probably represent the new generation of Spot-tail mantis shrimps whose larvae settled on the bottom in late summer and early autumn of the same year. The results of the study indicate that the growth rate is similar for males and females, both sexes reaching around 18 mm CL at the end of the first year of life and around 32 mm CL at the end of the third year of life. It seems that mantis shrimp individuals live up to five or six years of age. The Von Bertalannfy (VBGF) parameters were computed using the above data and are presented in Table 5.2.7.2.1.

Tab. 5.2.7.2.1. Spot-tail mantis shrimp in GSA 17. Von Bertalanffy growth parameters.

Linf	K	t_0
41.53	0.49	-0.0105

a and b for the length-weight relationship were provided from Italy: the values for 2014 are shown in table 5.2.7.2.2.

Tab. 5.2.7.2.2. Spot-tail mantis shrimp in GSA 17. Parameters of the length weight relationship.

a	**b**
0.01333	2.3994

Maturity

Females with mature ovaries and active (white) cement glands are observed in late winter in the Central Adriatic. Spent females with still whitish glands are usually observed from April to September when the sex ratio (M/F) is strongly in favour of males (Piccinetti and Piccinetti Manfrin, 1971; Froglia *et al.*, 1996). Females reach maturity in their second year of life in GSA 17 and the mean size of mature females is around 29 mm CL.

The maturity vector used in the assessment is shown in table 5.2.7.3.1. as reported in the DCF database for *S. mantis* in GSA 18.

Tab. 5.2.7.3.1. Spot-tail mantis shrimp in GSA 17. Maturity vector by age.

Age	**Maturity**
0	0.003
1	0.809
2	1
3	1
4	1
5	1
6	1
7	1
8+	1

Natural mortality

Natural mortality as obtained from PRODBIOM model (Abella *et al.*, 1998) is shown in table 5.2.7.4.1.

Tab. 5.2.7.4.1. Spot-tail mantis shrimp in GSA17. Mortality by age.

Age	**M**

0	1.2
1	0.7
2	0.6
3	0.52
4	0.5
5	0.48
6	0.48
7	0.48
8+	0.48

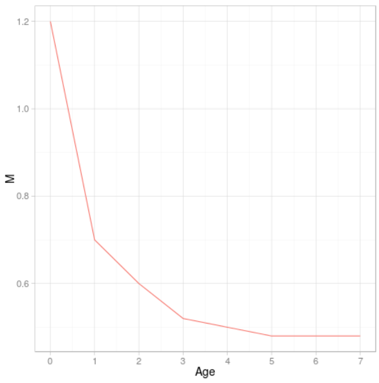


Fig. 5.2.7.4.1. Spot-tail mantis shrimp in GSA 17. Mortality by age.

Fisheries

5.2.7.1.1 General description of the fisheries

Although *S. mantis* ranks first among the crustaceans landed in the Adriatic ports of GSA 17, it is not the target of a specialized fishery, but it is an important component of local multispecies trawl and gill net fisheries. It is caught by 4 fisheries, namely DEMF, DEMSP, MDPSP and SPF within which 10 different fishing gears are being used.

Only in the Gulf of Trieste it is the target of a small artisanal fishery with creels (Froglia and Giannini, 1989). The Italian annual landing for 2014 comes for 83% from the bottom otter trawls (2,326 tons), 11% from the gillnett (296 tons) and for 6% from *rapido* trawl (184 tons).

The species is absent from the landings statistic of Croatia (FAO-FISHSTAT J – GFCM Database) and it accounted only for 0.5 tons in the Slovenian catches of 2014 (2014 DCF data). The species is not present in the list of shared stock of GFCM.

Catches show marked dial periodicity with significantly more animals caught at night (Froglia and Giannini, 1989; Froglia and Gramitto, 1989). The burrowing behaviour of *S. mantis* makes it vulnerable only when individuals are out of their burrows and this occurs mainly at night, between sunset and sunrise. Seasonal variations in catchability result from reduced out-of-burrow activity, because females rarely exit their burrow when they are incubating their egg mass in spring and early summer. Conversely, catches increases in winter, when mating takes place. Catches increase further in late autumn with the arrival of new recruits. The reproductive behaviour of the species also influences the relative proportion of males and females in the catches by season: females outnumber males only in winter (mating season), while the sex-ratio is biased towards males in spring and summer. Additionally, weather and sea conditions represent an important influence on the catchability of this species as catches increase after prolonged bad weather conditions probably because of disturbance of the burrow systems as a result of the high turbidity (Froglia *et al*., 1996).

5.2.7.1.2 Management regulations applicable in 2015

Italy and Slovenia

- Minimum landing sizes: none.
- Fishing closure for trawling: 30-45 days in late summer (not every year the same).
- Cod end mesh size of trawl nets: 40 mm (stretched, diamond meshes) till 30/05/2010. From 1/6/2010 the existing nets have been replaced with a cod end with 40 mm (stretched) square meshes or a cod end with 50 mm (stretched) diamond meshes.
- Towed gears are not allowed within three nautical miles from the coast or at depths less than 50 m when this depth is reached at a distance less than 3 miles from the coast. However, towed gears are always forbidden inside 1.5 miles from the coast with the exception of some areas of the GSA 17 that have benefited from the derogation according by the EC Regulation 1967/2006 for the Mediterranean Sea.
- Minimum mesh size for gill net (16 mm stretched). The mesh size used by set netters targeting sole and squilla range from 32 mm, hence larger than the legal minimum mesh size.
- Maximum length of nets x vessel x day (5,000 m).

5.2.7.1.3 Catches

Catch data are available for Italy since 2007 and for Slovenian starting in 2005. No fishery is reported for Croatia. Catch from Slovenia are negligible compared to the ones from Italy, therefore the data used goes from 2007 to 2014 (Table 5.2.7.5.3.1.).
No size structure of the catch was available for Slovenia.
After exploring the Length Frequency Distribution (LFD) of the landings, it was agreed in discarding the 2007 data, since a clear difference in the shape of the distribution is observed (figure 5.2.7.5.3.1.). This might have been caused by different measurements methodology (e.g. inclusion or not of the rostral plate). This issue should be further investigated.

Tab. 5.2.7.5.3.1. Spot-tail mantis shrimp in GSA 17. Total catches (in tonnes) from 2007 to 2014.

Year	Total Catches
2007	4309
2008	4411
2009	4992
2010	4945
2011	4512
2012	3209
2013	2384
2014	3205

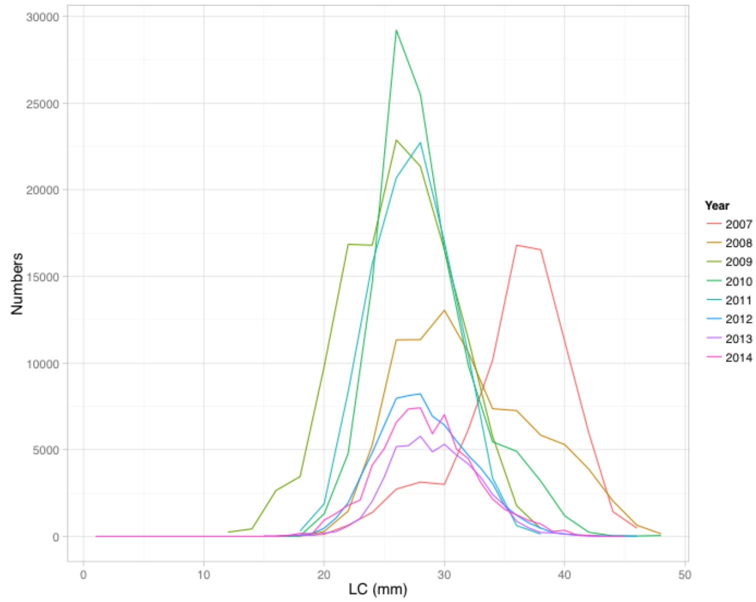


Fig. 5.2.7.5.3.1. Spot-tail mantis shrimp in GSA 17. Length Frequency Distribution of catches from 2007 to 2014.

No age structure of catches was available in the DCF database, therefore catch at age data have been reconstructed using the VB growth parameters described in the previous section and the LFDA5 software. A statistical slicing have been attempted as well, but due to the lack of different modes in the size distribution, the methodology did not work.
The internal consistency of the age data is low (figure 5.2.7.5.3.1.): only ages 0 and 1 are somehow well tracked in the catch data.

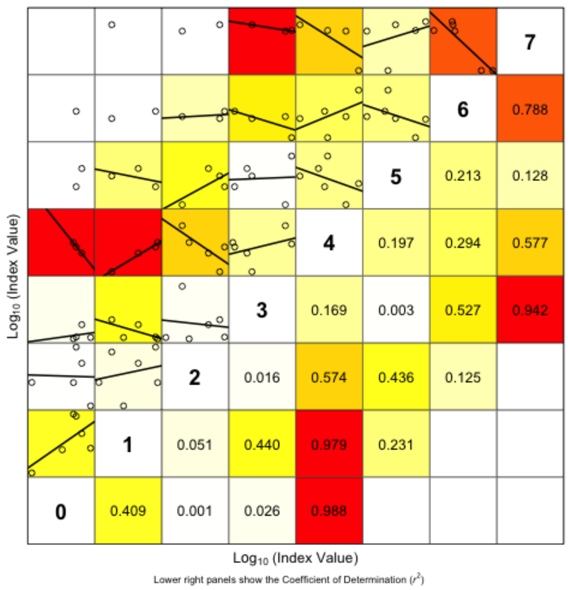


Fig. 5.2.7.5.3.1. Spot-tail mantis shrimp in GSA 17. Catch at age between-year consistency plot.

The trend in the cohorts is shown in figure 5.2.7.5.3.2. Age 2 is the fully recruited age in most years.

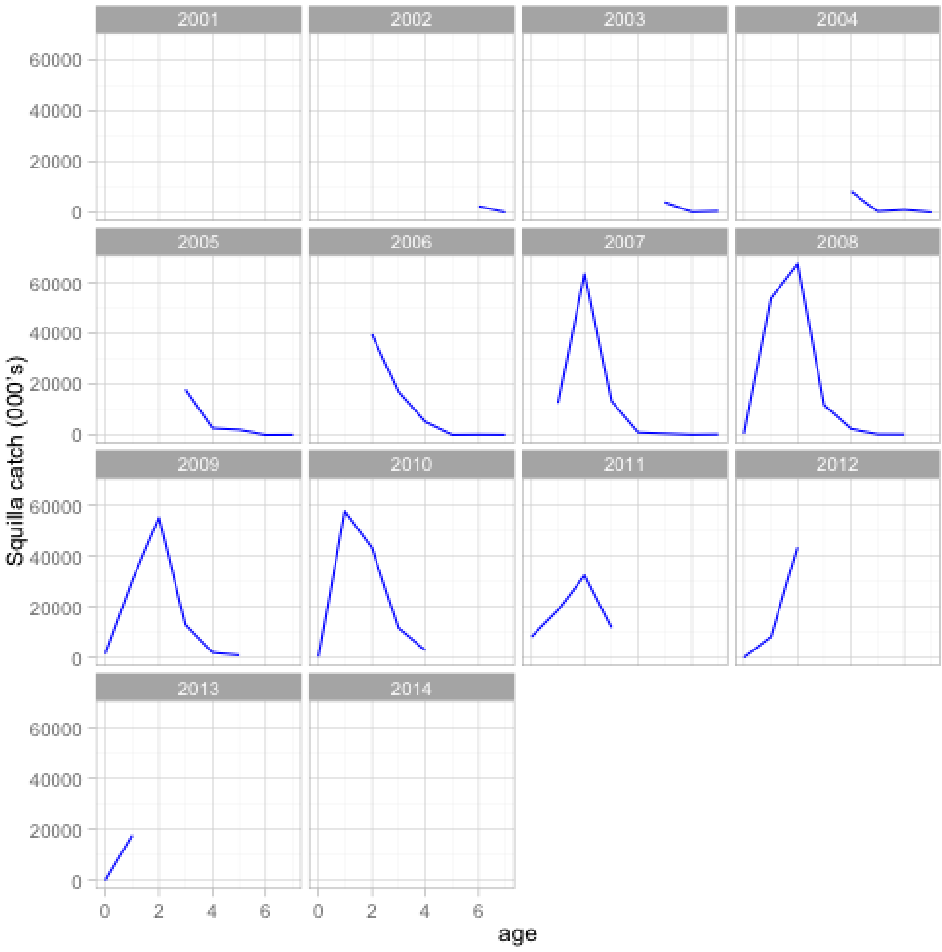


Fig. 5.2.7.5.3.2. Spot-tail mantis shrimp in GSA 17. Catch-at-age cohort plots from 2008 to 2014.

Numbers at age in the catch along the years is shown in figure 5.2.7.5.3.3.

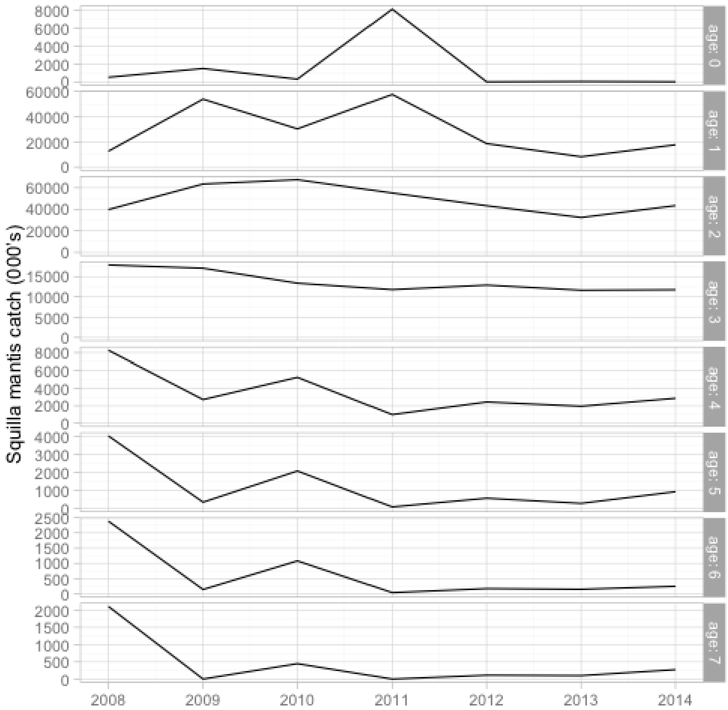


Fig. 5.2.7.5.3.3. Spot-tail mantis shrimp in GSA 17. Trend in numbers at age in the catch from 2008 to 2014.

5.2.7.1.4 Landings

The landings show a slight increase in the first part of the time series, followed by a strong decrease between 2010 and 2013. In 2014 a slight increase has been registered. The trend is shown in table 5.2.7.5.4.1 and in figure 5.2.7.5.4.1.

Tab. 5.2.7.5.4.1. Spot-tail mantis shrimp in GSA 17. Landings (in tonnes) from 2007 to 2014.

Year	Tonnes
2007	3912
2008	4005
2009	4533
2010	4570
2011	3790
2012	3106
2013	2128
2014	2806

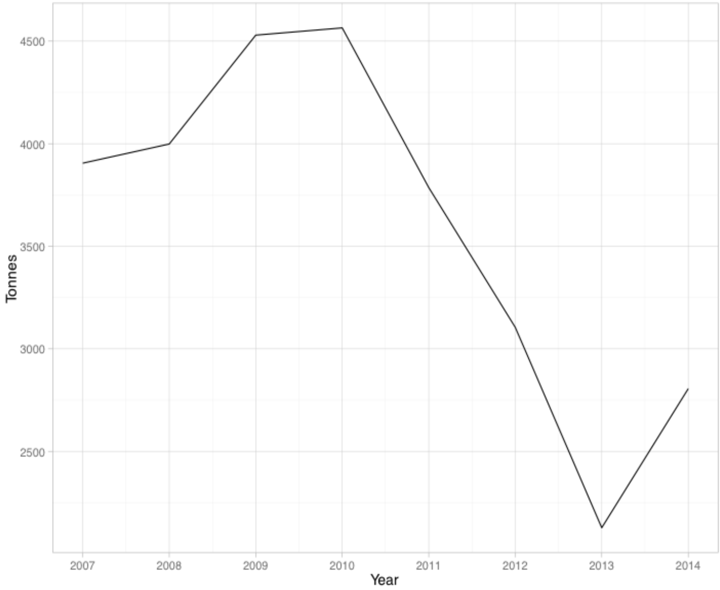


Fig. 5.2.7.5.4.1. Spot-tail mantis shrimp in GSA17. Trend in landings (in tonnes) from 2007 to 2014.

In table 5.2.7.5.4.2 the landings by fleet and gear are reported.

Tab. 5.2.7.5.4.2. Spot-tail mantis shrimp in GSA 17. Landings by fishing fleet and gear from 2005 to 2014.

	Slovenia									Italy		
Year	**FPO**	**FYK**	**GND**	**GNS**	**GTR**	**LLS**	**OTB**	**OTM**	**PS**	**GNS**	**OTB**	**TBB**
2005	0.665	-	-	0.197	0.536	NA	3.164	-	-	-	-	-
2006	0.444	-	-	0.162	0.275	0.013	1.529	-	-	-	-	-
2007	0.317	-	0.003	0.352	0.503	0	6.069	-	0.001	936	2969	-
2008	0.446	-	-	0.867	1.193	-	3.717	-	0.002	831	2859	309
2009	0.284	-	-	0.493	0.617	0	2.21	0.025	-	872	3167	490
2010	0.416	0.003	-	0.339	0.995	-	3.241	-	-	961	3163	440
2011	0.775	0.002	-	0.184	0.417	0	2.210	-	-	1136	2399	251
2012	0.050	0.001	-	0.092	0.214	0.010	0.361	-	-	1141	1681	283
2013	0.048	-	-	0.045	0.094	0.004	0.111	-	-	205	1682	240
2014	0.027	-	-	0.021	0.120	-	0.31	-	-	296	2326	184

A sudden drop in the landigs of Italian GNS occurs in 2013, and the GNS contribution remains low in 2014 as well (Figure 5.2.7.5.4.2). This event might be connected to a general decrease in effort of GNS (nominal effort, gt per days and number of vessels) observed in 2013. Italian OTB on the other hand, show a decrease in landings starting in 2010 until 2013, and then rise again to more than 2,000 tonnes in 2014. Landings of Slovenian OTB show a constant decreasing trend from the beginning of the time series, which from 2011 is correlated with a general decrease of effort.

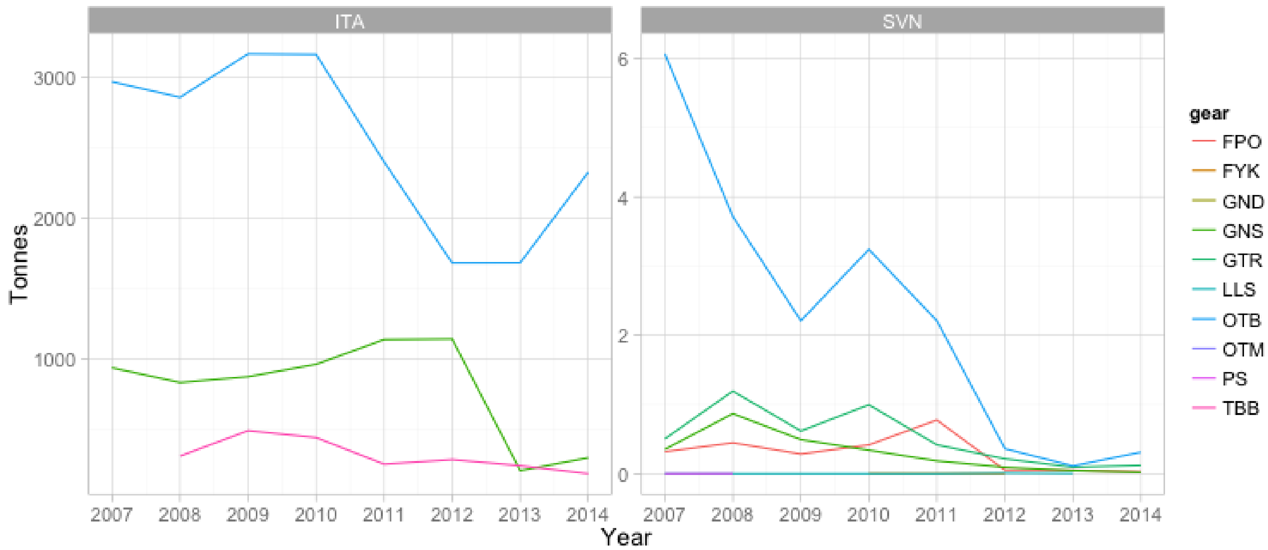


Fig. 5.2.7.5.4.2. Spot-tail mantis shrimp in GSA 17. Trend in landings (in tonnes) by fishing fleet and fishing gear from 2007 to 2014.

5.2.7.1.5 Discards

Discard is available for Slovenia starting in 2005, and for Italy from 2010 to 2014. Slovenian discard is less than 1% of the total. The discard before 2010 for Italy has been reconstructed assuming an average percentage of 10% over the landings (average contribution of discard from 2010 to 2014, table 5.2.7.5.5.1.). Size structure of discard is available for Italy only from 2010 to 2014, therefore the size and age structure before that were reconstructed using an average proportion from 2010 to 2014.

Tab. 5.2.7.5.5.1. Spot-tail mantis shrimp in GSA 17. Total tonnes of discard for Italy and Slovenia from 2007 to 2014. Italian data until 2009 have been reconstructed.

Year	Tonnes
2007	397
2008	406
2009	459
2010	375
2011	722
2012	103
2013	256
2014	399

The main contribution to the discard is given from Italian OTB (table 5.2.7.5.5.2. and figure 5.2.7.5.4.1.).

Tab. 5.2.7.5.5.2. Spot-tail mantis shrimp in GSA17. Discard (in tonnes) for Italy and Slovenia by gear from 2005 to 2014.

	Slovenia			Italy		
year	**GNS**	**GTR**	**OTB**	**GNS**	**OTB**	**TBB**
2005	0.001	0.000	0.410	-	-	-
2006	0.000	0.000	0.125	-	-	-

2007	0.006	0.000	0.880	-	-	-
2008	0.038	0.000	0.506	-	-	-
2009	0.005	0.000	0.294	-	-	-
2010	0.000	0.001	0.438	-	375	-
2011	0.000	0.000	0.260	0.945	705	16.102
2012	0.004	0.000	0.014	-	103	-
2013	0.000	0.000	0.001	-	258	-
2014	0.000	0.001	0.009	-	394	4.279

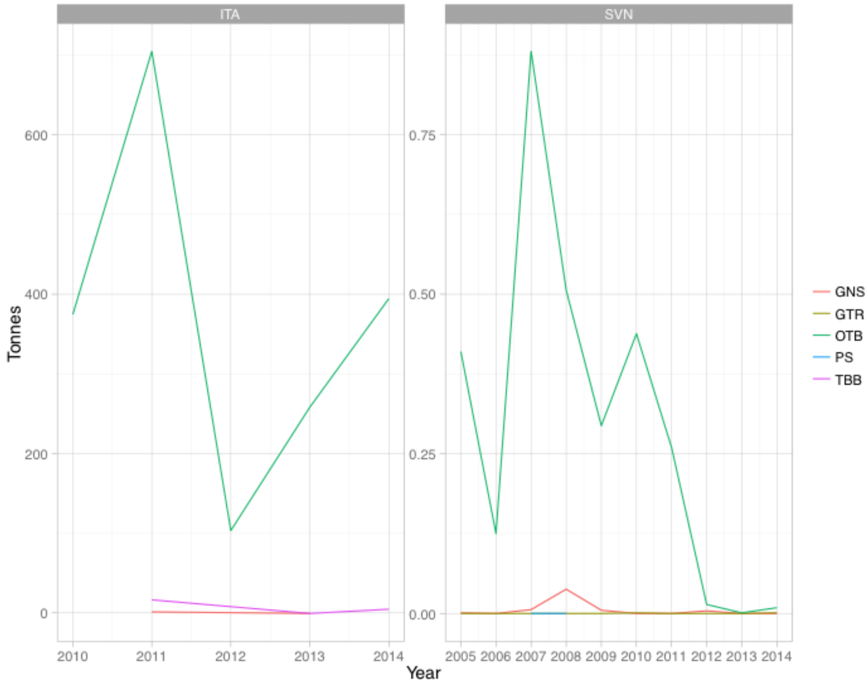


Fig. 5.2.7.5.4.1. Mantis shrimp in GSA17. Trend in discard (in tonnes) by fishing fleet and gear from 2005 to 2014.

The length frequency observed in the discard is shown in figure 5.2.7.5.4.1.

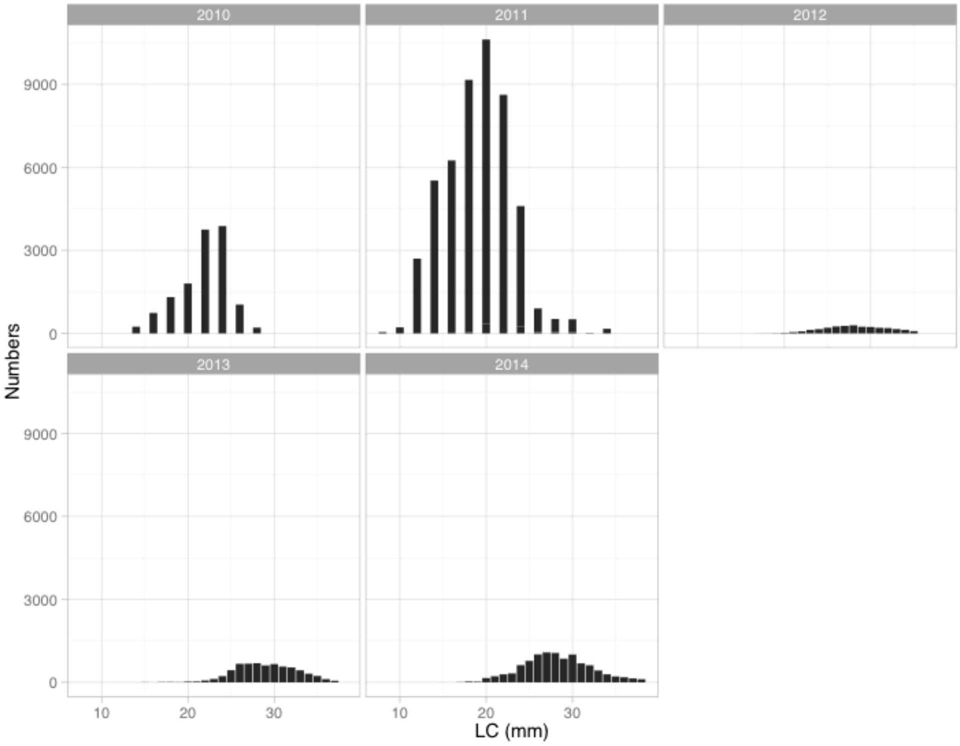


Fig. 5.2.7.5.4.1. Mantis shrimp in GSA17. Length frequency distribution of Italian discard from 2010 to 2014. No size structure is available for Slovenia.

5.2.7.1.6 Fishing effort (by fleet if possible)

About 350 bottom otter trawlers exploit this resource all year round. Spot-tail mantis shrimp is caught as a part of a species mix that constitutes the target of the trawlers operating on the continental shelf. The main species caught in GSA 17 associated with mantis shrimp are *Sepia officinalis, Trigla lucerna, Merluccius merluccius, Mullus barbatus* and *Eledone* spp*.* Trawl catch is mainly composed by age 1 and 2 individuals while the older age classes are poorly represented in the catch. As concerns artisanal fisheries, *S. mantis* is a by catch (only in few cases it also targeted) of gillnetters targeting *Solea solea*, especially during spring-summer seasons in the coastal area (GFCM-WGSADS, 2012).

Table 5.2.7.5.6.1. Spot-tail mantis shrimp in GSA17. Fishing effort and fleet size for the mixed fishery fleet catching *S.mantis* for Italy and Slovenia for the period 2004 – 2014. The average for Italy is calculated between OTB, TBB and GNS.

Year	Nominal effort		Effort [gt days at sea]		Average number of vessels	
	ITA	SLO	ITA	SLO	ITA	SLO
2004	9931583	-	1597112	-	274	
2005	9709799	250892	1751227	41634	277	10
2006	9302798	250751	1675881	38860	255	9
2007	8692946	323943	1677473	47252	270	11
2008	8808386	319846	1670159	41286	247	12
2009	8814977	365593	1674022	50101	275	11
2010	8382481	362472	1635720	47003	240	12
2011	7887204	456426	1449553	70352	242	11

2012	7428924	254897	1363936	17533	233	14
2013	6113861	251137	1155805	17511	245	14
2014	7237127	225634	1279080	14808	234	15

Table 5.2.7.5.6.2. Spot-tail mantis shrimp in GSA 17. Fishing effort in GT days at sea by fleet for the main gears targeting *S. mantis* in GSA 17 for the period 2004-2014.

GT days at sea

	ITA			SLO	
Year	**ITA - GNS**	**ITA - OTB**	**ITA - TBB**	**SLO - OTB**	**SLO - other**
2004	245185	3543021	1003129	-	0
2005	262674	4205417	785589	9155	74113
2006	215431	3759299	1052912	12291	65429
2007	156782	3779272	1096364	17413	77090
2008	134853	4031883	843741	18858	63715
2009	172839	3804025	1045203	18191	82011
2010	190127	3795874	921158	18235	75770
2011	236241	3447262	665155	17782	122922
2012	258525	3060578	772706	15063	20003
2013	167797	2642061	657556	11960	23063
2014	233376	2711270	892595	9372	20244

Table 5.2.7.5.6.3. Spot-tail mantis shrimp in GSA 17. Nominal fishing effort in Kw days at sea by fleet for the main gears targeting *S. mantis* in GSA 17 for the period 2004-2014.

Nominal Effort [Kw days at sea]

	ITA			SLO	
Year	**ITA - GNS**	**ITA - OTB**	**ITA - TBB**	**SLO - OTB**	**SLO - other**
2004	4474535	21087676	4232537		0
2005	4980544	20335938	3812915	112663	389120
2006	4304857	18657299	4946237	143526	357976
2007	2538855	18308149	5231834	183978	463909
2008	2446686	19842127	4136346	198181	441511
2009	3270215	18788561	4386154	200880	530306
2010	3394794	17935158	3817491	207862	517082
2011	4642260	16434634	2584717	188621	724230
2012	5280623	13751962	3254187	153646	356149
2013	2974353	12597554	2769675	113694	388581
2014	3864370	14117196	3729815	99847	351421

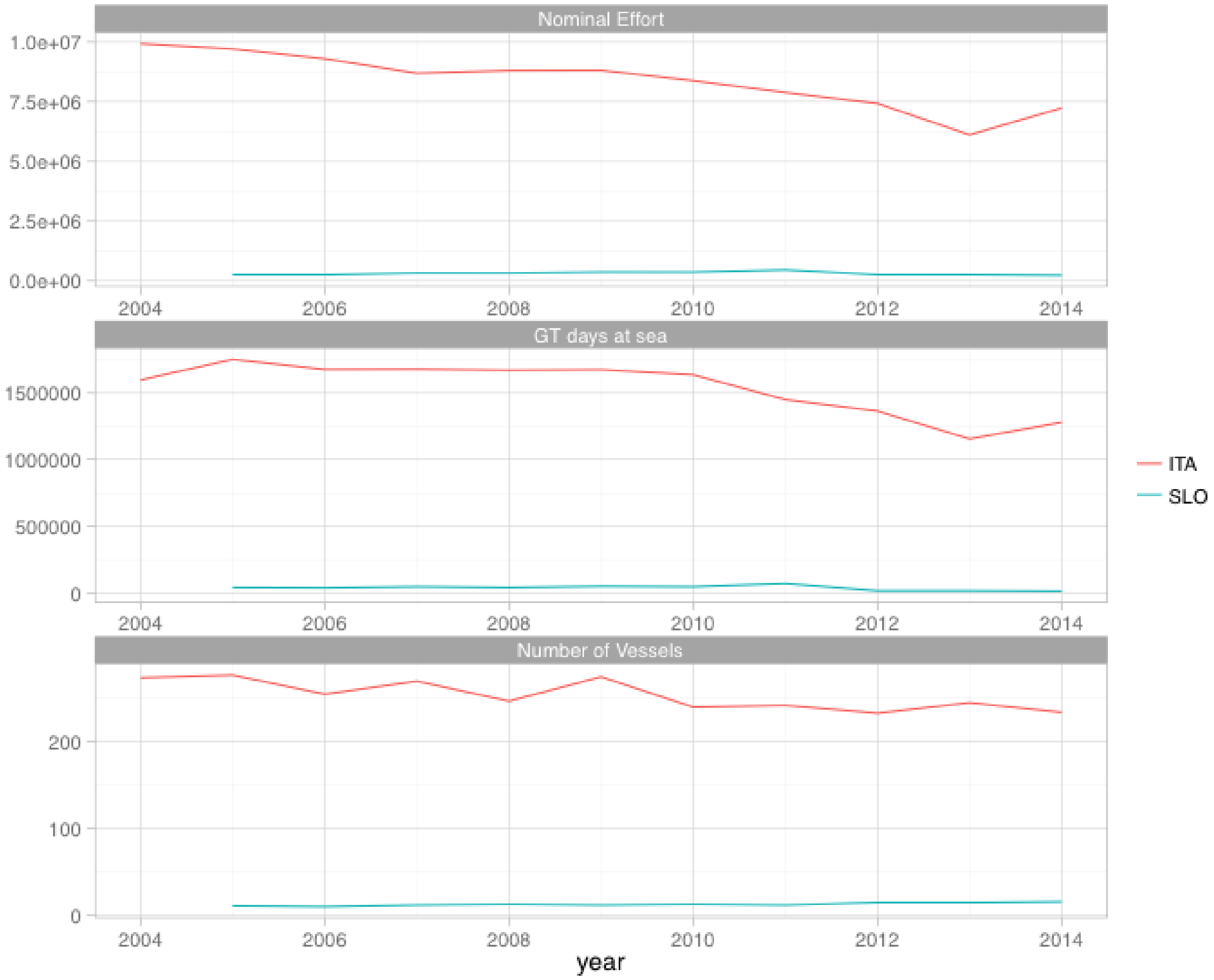


Fig. 5.2.7.5.6.1. Spot-tail mantis shrimp in GSA 17. Fishing effort and fleet size for the mixed fishery fleet catching *S.mantis* for Italy and Slovenia for the period 2004 – 2014.

Scientific surveys

5.2.7.1.7 Survey #1 (SOLEMON)

Nine *rapido* trawl fishing surveys were carried out in GSA 17 from 2005 to 2014: two systematic "pre-suveys" (spring and fall 2005) and four random surveys (spring and fall 2006, fall 2007-2014) stratified on the basis of depth (0-30 m, 30-50 m, 50-100m). Hauls were carried out by day using 2-4 *rapido* trawls simultaneously (stretched codend mesh size = 40.2 ± 0.83). The following number of hauls was reported per depth stratum (Tab. 5.2.7.6.1.1.).

Tab. 5.2.7.6.1.1. Spot-tail mantis shrimp in GSA 17. MEDITS number of hauls per year and depth stratum in GSA 17, 2005-2011.

Depth strata	Spring 2005	Fall 2005	Spring 2006	Fall 2006	Fall 2007	Fall 2008-2011
0-30	30	30	20	35	32	39
30-50	14	12	10	20	19	17

50-100	24	15	8	8	11	11
HR islands	0	5	4	4	0	0
TOTAL	68	62	42	67	62	67

Abundance and biomass indexes from *rapido* trawl surveys were computed using ATrIS software (Gramolini *et al*., 2005) which also allowed drawing GIS maps of the spatial distribution of the stock, spawing females and juveniles. Underestimation of small specimens in catches due to gear selectivity was corrected using the selective parameters given by Ferretti and Froglia (1975).
The abundance and biomass indices by GSA 17 were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum area in the GSA 17:

$Yst = \Sigma (Yi*Ai) / A$
$V(Yst) = \Sigma (Ai^2 * si^2 / ni) / A^2$

Where:
A=total survey area
Ai=area of the i-th stratum
si=standard deviation of the i-th stratum
ni=number of valid hauls of the i-th stratum
n=number of hauls in the GSA
Yi=mean of the i-th stratum
Yst=stratified mean abundance
V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval:

Confidence interval = Yst ± t(student distribution) * V(Yst) / n

It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution, quasi-poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial (e.g. O'Brien *et al.*, 2004). Length distributions represented an aggregation (sum) of all standardized length frequencies over the stations of each stratum and are available from 2009. Aggregated length frequencies were then raised to stratum abundance and finally aggregated (sum) over the strata to the GSA. Given the sheer number of plots generated, these distributions are not presented in this report.
Table 5.2.7.6.1.2. and Figure 5.2.7.6.1.1. show the abundance indices of mantis shrimp obtained from SOLEMON survey from 2005 to 2014.

Tab. 5.2.7.6.1.2. Spot-tail mantis shrimp in GSA 17. Index of abundance from SOLEMON survey from 2005 to 2014.

Year	N/km^2
2005	549
2006	318
2007	98
2008	303
2009	511

2010	567
2011	525
2012	418
2013	606
2014	642

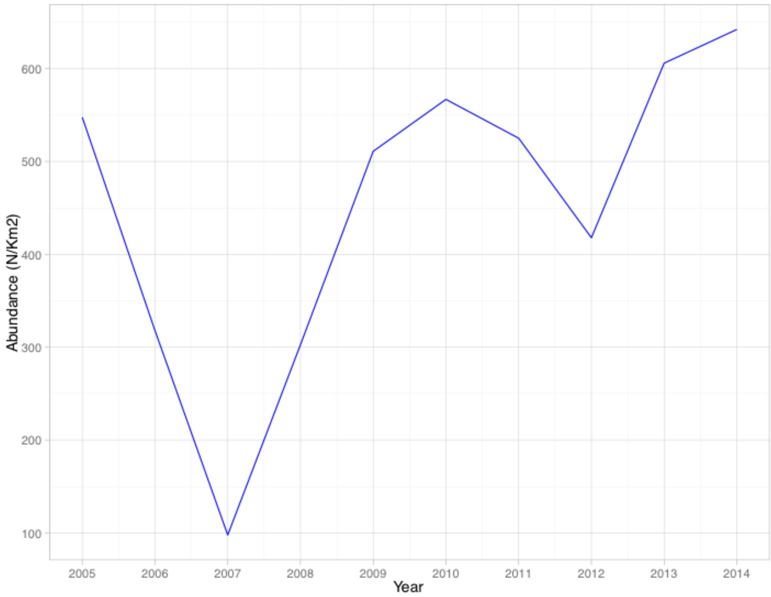


Fig. 5.2.7.6.1.1. Spot-tail mantis shrimp in GSA 17. Index of abundance from SOLEMON survey from 2005 to 2014.

Figure 5.2.7.6.1.2 displays the stratified abundance indices by size obtained in GSA 17 from 2009 to 2014 during fall survey.

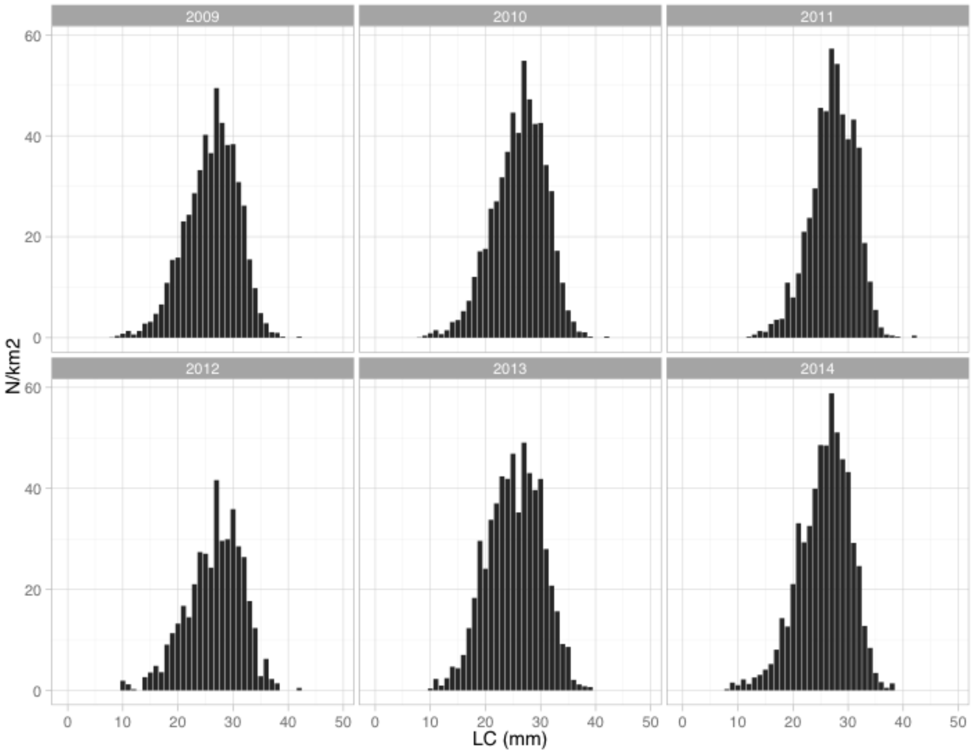


Fig. 5.2.7.6.1.2. Spot-tail mantis shrimp in GSA 17. Stratified abundance indices by size from SOLEMON survey, 2009-2014.

The consistency plot (Fig. 5.2.7.6.1.3.) drew for the sliced numbers at age of the SOLEMON survey show difficulties in tracking the cohorts along the year.

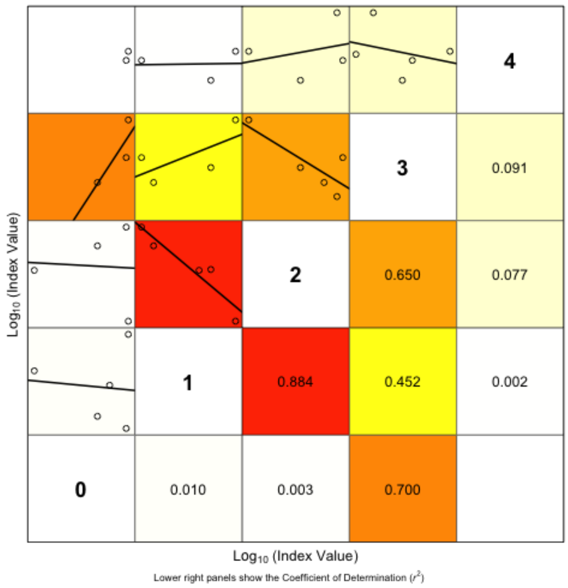


Fig. 5.2.7.6.1.3. Spot-tail mantis shrimp in GSA 17. Between-year consistency plot of numbers-at-age from SOLEMON survey.

5.2.7.1.8 Survey #2 (MEDITS)

Based on the DCF data call, abundance and biomass indices were recalculated. In GSA 17 the following number of hauls was reported per depth stratum (see table 5.2.7.7.1.1.).

Tab. 5.2.7.7.1.1. Spot-tail mantis shrimp in GSA 17. Number of hauls per year and depth stratum in GSA 17 from 2006 to 2013.

Year	10-50m	50-100m	100-200m	200-500m	Total
2006	60	66	43	11	180
2007	67	60	45	10	182
2008	65	64	43	10	182
2009	63	66	43	11	183
2010	65	59	49	9	182
2011	62	64	49	10	185
2012	62	63	46	11	182
2013	69	53	46	12	239

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Few obvious data errors were corrected. Catches by haul were standardized to 60 minutes hauling duration.

The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

$Yst = \Sigma (Yi*Ai) / A$

$V(Yst) = \Sigma (Ai^2 * si^2 / ni) / A^2$

Where:

A=total survey area
Ai=area of the i-th stratum
si=standard deviation of the i-th stratum
ni=number of valid hauls of the i-th stratum
n=number of hauls in the GSA
Yi=mean of the i-th stratum
Yst=stratified mean abundance
V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval =

Yst ± t(student distribution) * V(Yst) / n

It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution, quasi-poisson. Indeed, data may be better modeled using the idea of conditionality and the negative binomial (e.g. O'Brien et al. (2004)).

Length distributions represented an aggregation (sum) of all standardized length frequencies (subsamples raised to standardized haul abundance per hour) over the stations of each stratum. Aggregated length frequencies were then raised to stratum abundance * 100 (because of low numbers in most strata) and finally aggregated (sum) over the strata to the GSA. Given the sheer number of plots generated, these distributions are not presented in this report. To extract the standardized LFD data, the R-file provided during the meeting was used.
The resulting length frequency distribution shows some issues, in particular:

- 2010 is missing;
- Big shift in size between 2009 and 2011: the only explanation is that the observers changed the measuring methodology, from Carapace length (which is usually the common way of measuring crustaceans) to total length (figure 5.2.7.6.2.1);
- The number of specimen measured in 2009, 2011 and 2013 is really low (figure 5.2.7.6.2.2.), maybe due to the paucity of individuals in the catches.

MEDITS survey was therefore deemed inappropriate to be used as tuning index of mantis shrimp in GSA17.

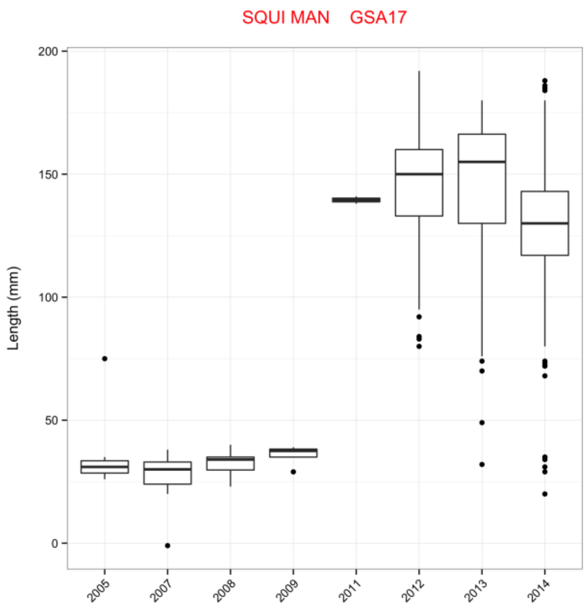


Fig. 5.2.7.6.2.1. Spot-tail Mantis shrimp in GSA 17. Mean length of the stratified index of abundance from MEDITS survey, 2005-2014.

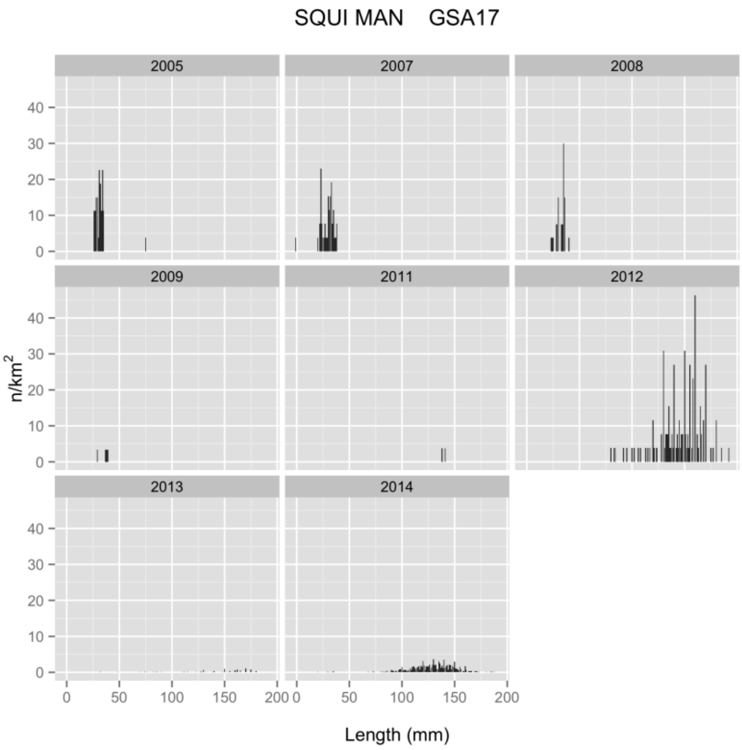


Fig. 5.2.7.6.2.2. Spot-tail Mantis shrimp in GSA 17. Stratified abundance indices by size from MEDITS survey, 2005-2014.

Stock Assessment

During EWG 15-16 the stock assessment was performed over the period 2008-2014: 2007 was excluded from the assessment due to the problems in the LFD highlighted in the data section. The age classes considered range from 0 to 8: plug group was set at age 7. The SOLEMON trawl survey was used as tuning index of the assessment and the age range used goes from 0 to 4, considering that older age classes are not so well represented.

5.2.7.1.9 Methods

XSA stock assessment model run throught the FLXSA library implemented in R (R version 3.2.2).

5.2.7.1.10 Input data

The following tables (from table 5.2.7.7.2.1 to table 5.2.7.7.2.3.) show the input data used in the XSA assessment.

Tab. 5.2.7.7.2.1. Spot-tail mantis shrimp in GSA 17. Total catches in tonnes from 2008 to 2014.

Year	Tonnes
2008	4411
2009	4992
2010	4945
2011	4512
2012	3209
2013	2384
2014	3205

Tab. 5.2.7.7.2.2. Spot-tail mantis shrimp in GSA 17. Numbers at age in the catches (thousands) from 2008 to 2014. SOP correction was applied.

Age	2008	2009	2010	2011	2012	2013	2014
0	506	1492	301	8126	0.2	35	4
1	12598	53889	30316	57608	18632	8196	17685
2	39697	63448	67431	55092	43258	32345	43372
3	17866	17065	13382	11794	12910	11642	11757
4	8281	2706	5237	995	2430	1946	2856
5	4027	353	2084	90	573	288	934
6	2383	141	1080	39	170	148	246
7	109	0.2	446	0.2	111	100	273

Tab. 5.2.7.7.2.3. Spot-tail mantis shrimp in GSA17. Mean weight at age (kg) from 2008 to 2014.

Age	2008	2009	2010	2011	2012	2013	2014
0	0.0073	0.0073	0.0073	0.0073	0.0073	0.0088	0.0088
1	0.0271	0.0230	0.0268	0.0261	0.0264	0.0269	0.0257
2	0.0398	0.0392	0.0388	0.0394	0.0392	0.0396	0.0396
3	0.0600	0.0594	0.0596	0.0586	0.0592	0.0593	0.0589
4	0.0746	0.0746	0.0746	0.0746	0.0740	0.0739	0.0742
5	0.0847	0.0847	0.0847	0.0847	0.0838	0.0847	0.0836
6	0.0929	0.0929	0.0929	0.0929	0.0929	0.0929	0.0929
7	0.1100	0.1060	0.1047	0.1060	0.1068	0.1002	0.1022

5.2.7.1.11 Results

A sensitivity analysis testing different shrinkage weights was performed before running the final XSA (Sh 0.5, 1.0, 1.5, 2.0, 2.5 and 3.0). Also, a sensitivity analysis of the *rage* parameter between 1 and 2 and *qage* parameter between 2 and 3 was carried out. The analysis of the residuals show very similar patterns in all cases, with the exception of the models with *fse* = 0.5 and *rage* = 2. The option with *rage* = 1, *qage* = 2 and *fse*=2 was selected as the best run (also checking the retrospective pattern, that in this run was slightly better compared to the others). The 5 best runs are ranked and summarized in table 5.2.7.7.3.1. Residuals from tuning fleets (SOLEMON) per age and year were lower than 0.5 (absolute value) for all the year-age combinations, with the exception of age 4, constantly overestimated from the model (higher value = -2.11) due to the unability of SOLEMON survey to catch big animals.

Tab. 5.2.7.7.3.1. Spot-tail mantis shrimp in GSA 17. XSA run comparison: minimum, maximum and average residuals absolute value are shown as well.

	fse	rage	qage	Min Residual	Max Residual	Average (abs value)
Run13	2	1	2	-2.11	0.41	0.21
Run14	2.5	1	2	-2.11	0.41	0.20
Run4	2.5	1	3	-2.08	0.40	0.20
Run3	2	1	3	-2.09	0.40	0.21
Run2	1.5	1	3	-2.09	0.41	0.21

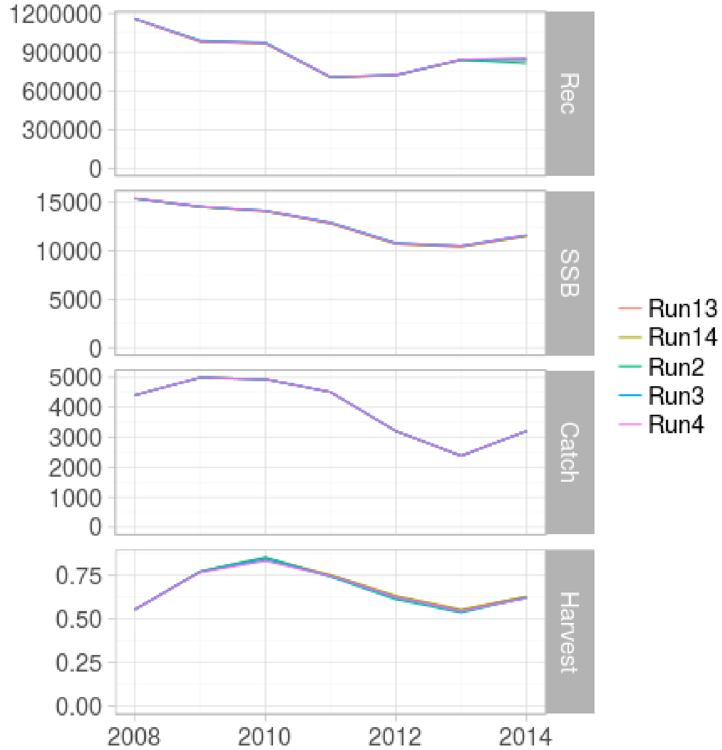


Fig. 5.2.7.7.3.1. Spot-tail mantis shrimp in GSA 17. XSA run comparison for R, SSB, Catch and F values.

XSA main outputs (Fig. 4.2.10.6.4.3 and tables 5.2.7.7.3.2., 5.2.7.7.3.3, 5.2.7.7.3.4) show a decrease in fishing mortality from 2010 till 2013, followed by a slight increase in 2014, which is equal to 0.63. Recruitment, after a decrease from 2008 to 2011, is quite stable in the last 4 years. SSB decreases from a value of 15414 to a value of 11536 in 2014.

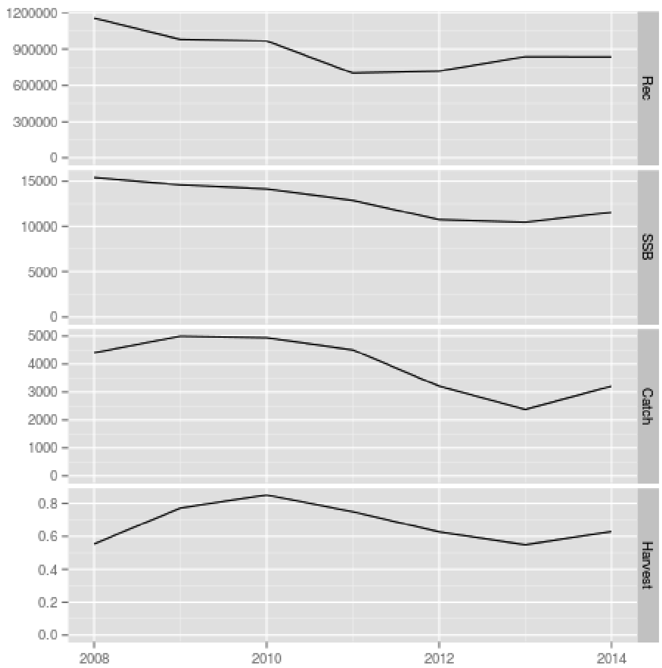


Fig. 5.2.7.7.3.2. Spot-tail mantis shrimp in GSA 17. XSA summary results. SSB and catch are in tonnes, recruitment in 1000s individuals.

Tab. 5.2.7.7.3.2. Spot-tail mantis shrimp in GSA 17. Fbar, Recruitment and SSB estimates by XSA 2008-2014.

Year	SSB	Recruitment	Fbar (1-3)
2008	15414	1155194	0.554
2009	14567	981882	0.772
2010	14111	967041	0.851
2011	12862	702296	0.750
2012	10736	718600	0.627
2013	10452	837765	0.549
2014	11536	836021	0.629

Tab. 5.2.7.7.3.3. Spot-tail mantis shrimp in GSA 17. Harvest by age estimates by XSA from 2008 to 2014.

Age	2008	2009	2010	2011	2012	2013	2014
0	0.0008	0.0028	0.0006	0.0213	0.0000	0.0001	0.0000
1	0.0662	0.2484	0.1577	0.3297	0.1366	0.0552	0.1048
2	0.6064	1.0803	1.1267	0.9027	0.8248	0.6670	0.8572
3	0.9902	0.9877	1.2674	1.0177	0.9200	0.9257	0.9251
4	1.1498	0.5563	1.9743	0.3797	0.9320	0.4762	0.9740
5	2.1755	0.1627	2.7426	0.1911	0.5694	0.3536	0.6498
6	1.4877	0.5829	2.0664	0.5786	1.0297	0.3860	0.8807
7	1.4877	0.5829	2.0664	0.5786	1.0297	0.3860	0.8807

Tab. 5.2.7.7.3.4. Spot-tail mantis shrimp in GSA 17. Stock numbers by age estimates by XSA from 2008 to 2014.

Age	2008	2009	2010	2011	2012	2013	2014
0	1155200	981880	967040	702300	718600	837770	836020
1	278990	347660	294920	291100	207070	216440	252310
2	117850	129660	134670	125090	103960	89697	101700
3	36868	35267	24158	23953	27837	25009	25265
4	15561	8143	7809	4044	5147	6595	5892
5	5775	2989	2832	658	1678	1229	2485
6	3913	406	1572	113	336	588	534
7	3243	1	596	1	209	387	567

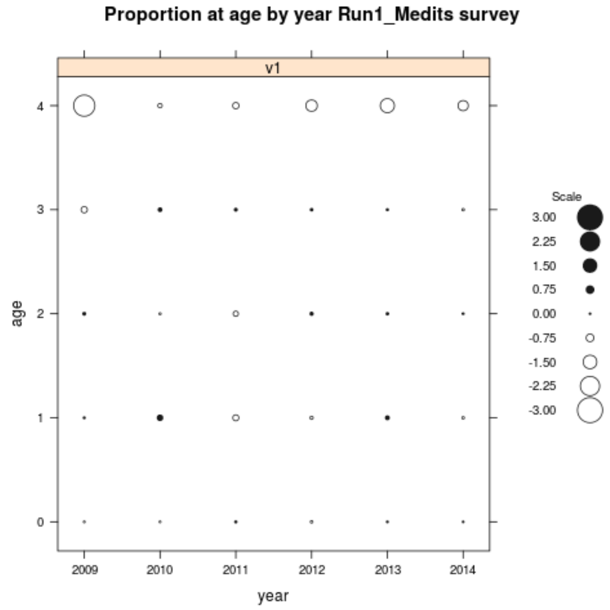


Fig. 5.2.7.7.3.3. Spot-tail mantis shrimp in GSA 17. Bubble plot of residuals of for the final model.

Retrospective analysis was carried out and the time series of estimates for assessments terminating in 2014, 2013 and 2012 are plotted. The retrospective series indicate good agreement between years in the assessment results with no systematic bias. The estimates derived from retrospective assessments are plotted in figure Fig. 5.2.7.7.3.4.

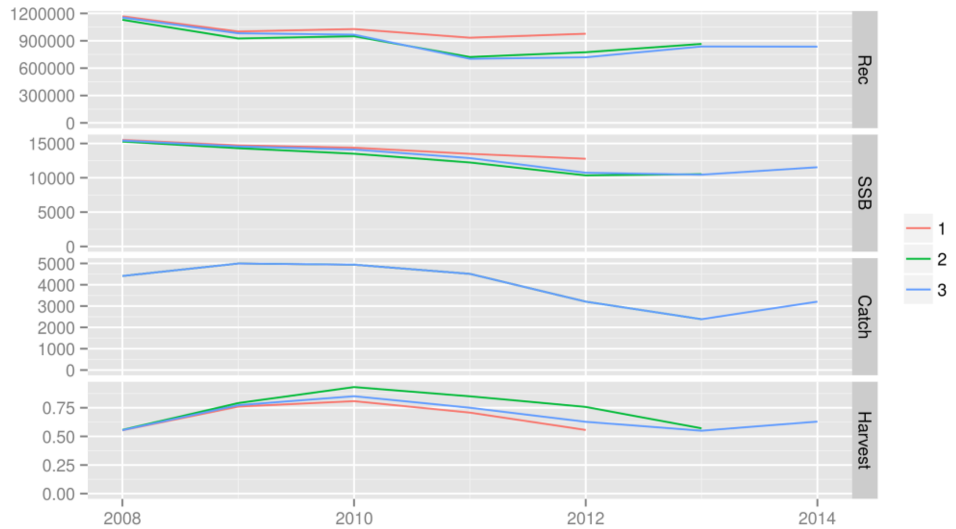


Fig. 5.2.7.7.3.4. Spot-tail mantis shrimp in GSA 17. Retrospective pattern of the final XSA run for the main variables (R, SSB and harvest).

Reference points

The yield per recruit (YpR) analysis was run using FLBRP routine. $F_{0.1}$ has been estimated equal to 0.52. $F_{current}$ (average of last two years) is equal to 0.59.

Data quality

Several issues has been identified in the data for *S. mantis* in GSA 17.

First of all, 2007 Italian landings data show a peculiar LFD, which seems to highlight some differences in the measuring methodology compared to the following years: therefore this year was discarded and not included in the assessment. Also, the sudden drop in GNS landings registered in 2013 should be further investigated.
MEDITS data for this species are considered completely unreliable for several reasons: a change in the measuring methodology between 2009 and 2011, the few numbers of specimens measured and the huge temporal extension of the MEDITS survey in 2014 (from May to November).

Short term predictions 2016-2018
A deterministic short term prediction for the period 2015 to 2017 was performed using the FLR routines provided by JRC, based on the results of the XSA stock assessments performed during EWG 15-16 for the years 2008–2014.

5.2.1.11.2 Input parameters

The same input parameters used in the XSA analysis showed above were used.

5.2.1.11.3 Results

Recruitment (class 0) has been estimated as the geometric mean of the last 2 years 2013-2014, taken from XSA results equal to 836893 (thousands).
A short term projection table (Table 5.2.7.7.3.4) assuming a F status quo = 0.59 (average Fbar of last 2 years) in 2015 and a recruitment of 836893 thousand individuals shows that:

- Fishing at F_{status_quo} from 2015 to 2017 would produce an increase in catches of about 9% and SSB would increase by 0.2% between 2016 and 2017.
- Fishing at F_{MSY} (0.48) from 2015 to 2016 would generate a decrease of 5.4% of the catches and an increase of 4% in SSB in 2017.
- Catches of mantis shrimp in 2016 consistent with F_{MSY} would not exceed 3032 tonnes.

Tab. 5.2.7.7.3.4. Spot-tail mantis shrimp in GSA 17. Short term forecast in different F scenarios. Basis: F(2015) = mean(Fbar1-3 2013-2014)= 0.59; R(2015) = geometric mean of the recruitment of the last 2 years; R = 836893 (thousands); SSB(2014) = 11536 t, Catch (2014)= 3205 t.

Rationale	Ffactor	Fbar	Catch 2014	Catch 2015	Catch 2016	Catch 2017	SSB 2016	SSB 2017	Change in SSB 2016-2017(%)	Change in Catch 2014-2016(%)
0 catch	0	0	3205	3430	0	0	12045	15581	29.36	-100
High long term yield ($F_{0.1}$)	0.82	0.48	3205	3430	3032	3223	12045	12534	4.07	-5.42
Status quo	1	0.59	3205	3430	3509	3520	12045	12072	0.23	9.46
Scenarios	0.1	0.06	3205	3430	455	645	12045	15115	25.49	-85.82
	0.2	0.12	3205	3430	882	1197	12045	14679	21.87	-72.5
	0.3	0.18	3205	3430	1283	1668	12045	14272	18.49	-59.98
	0.4	0.24	3205	3430	1660	2070	12045	13892	15.34	-48.21
	0.5	0.29	3205	3430	2015	2414	12045	13537	12.39	-37.13
	0.6	0.35	3205	3430	2350	2708	12045	13205	9.63	-26.69
	0.7	0.41	3205	3430	2665	2960	12045	12893	7.05	-16.86
	0.8	0.47	3205	3430	2962	3176	12045	12602	4.63	-7.58
	0.9	0.53	3205	3430	3243	3361	12045	12329	2.36	1.18
	1.1	0.65	3205	3430	3760	3656	12045	11831	-1.77	17.29
	1.2	0.71	3205	3430	3997	3773	12045	11605	-3.65	24.71
	1.3	0.76	3205	3430	4222	3874	12045	11392	-5.42	31.73
	1.4	0.82	3205	3430	4436	3961	12045	11192	-7.08	38.39
	1.5	0.88	3205	3430	4638	4036	12045	11003	-8.65	44.71
	1.6	0.94	3205	3430	4831	4102	12045	10825	-10.13	50.72
	1.7	1	3205	3430	5014	4158	12045	10656	-11.53	56.43
	1.8	1.06	3205	3430	5188	4208	12045	10497	-12.85	61.87
	1.9	1.12	3205	3430	5354	4251	12045	10347	-14.09	67.05
	2	1.18	3205	3430	5513	4289	12045	10205	-15.28	71.99

Short term predictions 2016-2018 by fleet

A deterministic short term prediction by fleet for the period 2015 to 2017 was performed using the FLR routines provided by JRC and based on the results of the XSA stock assessments performed during EWG 15-16.

5.2.1.11.2 Input parameters

The same parameters used in the short term by single fleet were used.

5.2.1.11.3 Results

Table 5.2.1.11.3.1. Spot-tail mantis shrimp in GSA 17. Short term forecast by fleet.

fleet	year	catches	partial_f
otb	2015	2409	0.410
other	2015	1021	0.178
otb	2016	2128	0.338
other	2016	904	0.146

otb	2017	2271	0.338
other	2017	952	0.146

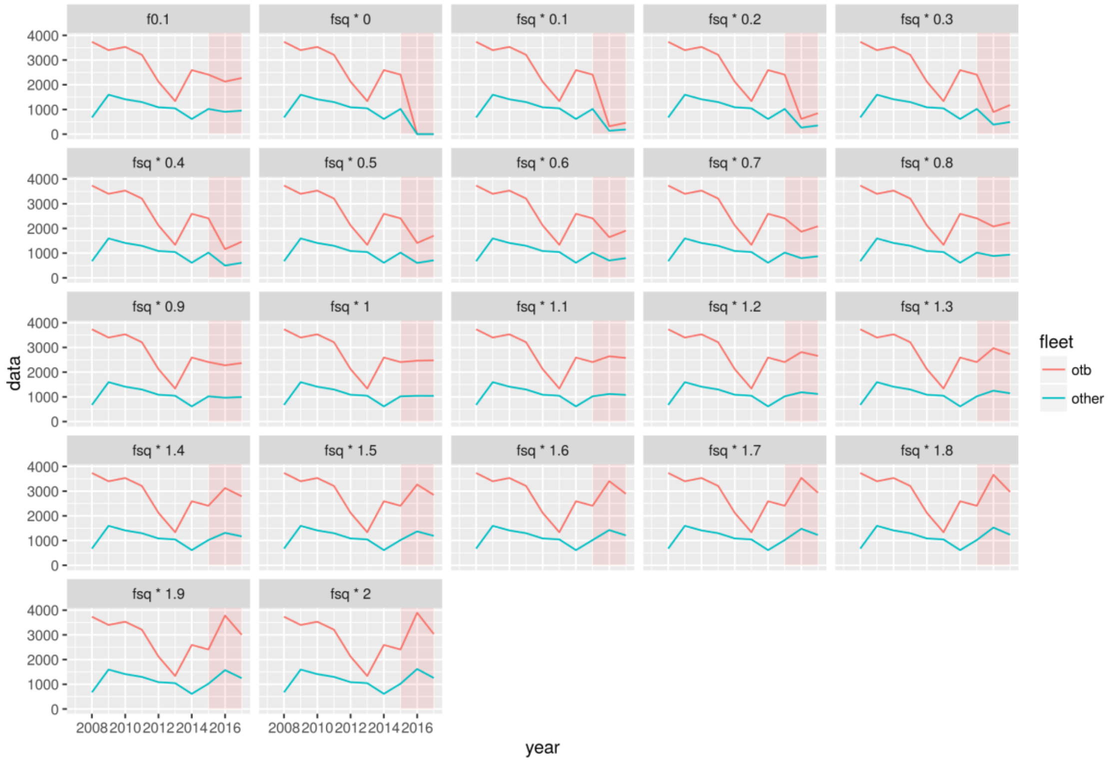


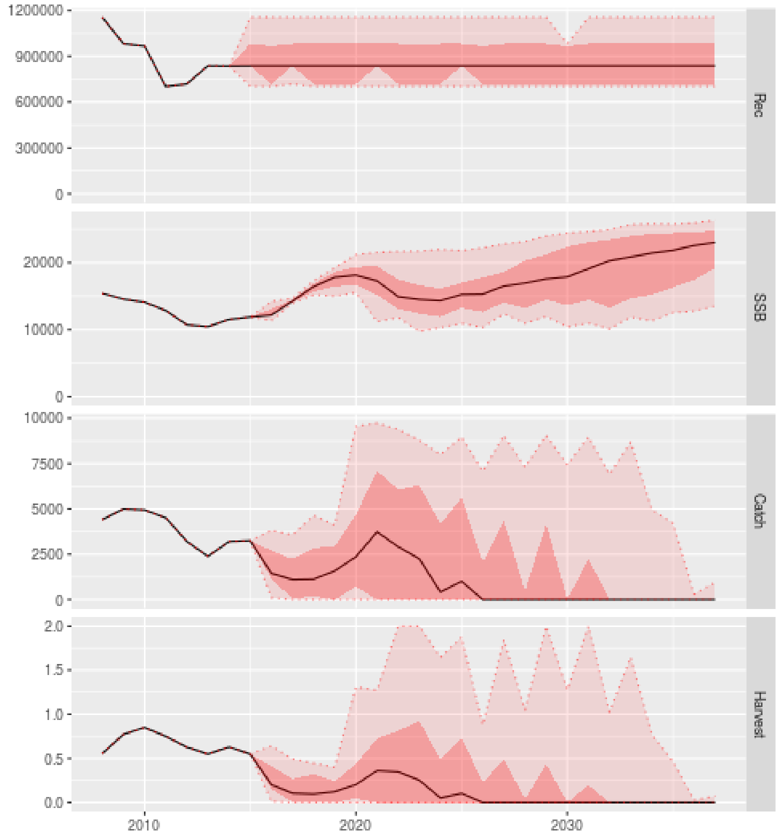
Figure 5.2.1.11.3.1. Spot-tail mantis shrimp in GSA 17. Short term forecast by fleet.

5.2.1.13 Stock advice

The current F (0.59) is larger than $F_{0.1}$ (0.48), chosen as proxy of F_{MSY} and as the exploitation reference point consistent with long term yields (F_{MSY}), which indicates that mantis shrimp in GSA 17 is being fished above F_{MSY}. Catches of *S. mantis* in 2016 consistent with F_{MSY} should not exceed 3032 tonnes.

5.2.1.14 MSE (Management strategy evaluations)

A Management Strategy Evaluation was run to evaluate if the F_{MSY} ranges were precautionary. The F_{MSY} ranges were derived using the formula provided by STECF EWG 15-16. F ranges results were F_{upper}=0.66 and F_{lower}=0.32. B_{lim} was estimated as B_{loss}= 125318 (t). B_{curr}(2014)=11536. The Figures 5.2.11.13.1 show the results of the MSE run with A4A. The results were not considered reliable, therefore the MSE cannot be used to determine the probability to fall below B_{lim} at F = F_{upper}.



1200000
900000
600000
300000
0
Rec
20000
10000
0
SSB
10000
7500
5000
2500
0
Catch
2.0
1.5
1.0
0.5
0.0
Harvest
2010
2020
2030

5.2.8 STOCK ASSESSMENT OF SPOT-TAIL MANTIS SHRIMP IN GSA 18

Stock Identification

The mantis shrimp is a benthic species, strongly related to bottom sediments, as demonstrated by its burrowing behaviour and by the composition of its diet. The species shows also a territorial pattern of behaviour. There are no studies dealing with the population structure of the spot-tail mantis shrimp in the Mediterranean and the Adriatic Sea. A single stock is assumed to occurr in GSA 18.

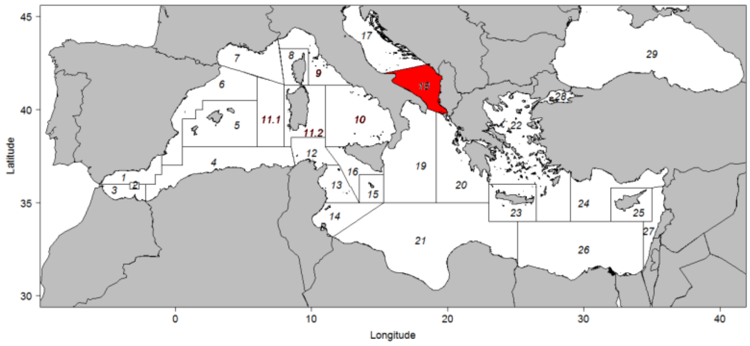


Figure 5.2.8.1.1. Geographical location of GSA 18.

Growth

The population at sea consists of 3 year-classes and the life span is estimated at about 3 years (Maynou et al., 2004). The population structure varies seasonally due to the incorporation of recruits (winter-spring) and the disappearance of adults (summer-autumn). Growth parameters used for the assessment L_∞=42.0, k=0.49, to=-0.2) are derived from Froglia (1996) who studied the species in the central-north Adriatic. The following length-weight relationship from the official data available during EWG 15-16 was used ($We=0.0021TL^{2.943}$).

Maturity

The life cycle of this species is well known: the spawning period is concentrated from winter to spring and planktonic larvae are found in summer, with the settlement of post-larvae occurring from the end of summer to mid-autumn. Recruitment to the fishery starts in late autumn, with full recruitment being reached between January and May (Maynou et al., 2004). In the central Adriatic, the peak of ovarian maturity was reported in February and March, when up to 80% of the females had ripe ovaries (Froglia, 1996). From April to September, mainly spent females were observed. According to Abelló and Martín (1993) and Froglia (1996), settlement of post-larvae takes place at the end of summer and the beginning of autumn at 17-20 mm Total Length (TL), or 3-4 mm Carapace Length (CL). In GSA 18 the monthly percentage of female maturity stages shows that the reproductive period extends from October to June with a peak during the coldest months (winter-early spring). L50 (±s.e.) for GSA 18 is 21.1 mm (Carbonara et al., 2013)

Natural mortality

Natural mortality was obtained from PRODBIOM assuming a maximum age of 7 years as shown in table above.

Age	0	1	2	3	4	5	6	7+
M	1.2	0.7	0.6	0.52	0.5	0.48	0.47	0.46

Fisheries

Mantis shrimp is mainly a by-catch of trawlers and to a much lesser extent by small scale fisheries using gillnets and trammel nets. Fishing grounds are located along the coasts of the whole GSA 18. The species is landed with other important commercial species such as *Mullus spp., Pagellus sp., Eledone moschata, Octopus vulgaris., M. merluccius*, etc.

5.2.8.1.1 General description of the fisheries

Fisheries in South Adriatic ccount for about 13% of the national annual production (Cataudella and Spagnolo, 2011). The exploitation of mantis shrimp is mainly exerted by the bottom trawlers, both on the western and the eastern sides.

5.2.8.1.2 Management regulations applicable in 2015

In Italy management regulations are based on technical measures, closed number of fishing licenses for the fleet and area limitation (distance from the coast and depth). In order to limit the over-capacity of fishing fleet, the Italian fishing licenses have been fixed since the late eighties and the fishing capacity has been gradually reduced. Other measures on which the management regulations are based regards technical measures (mesh size), minimum landing sizes (EC 1967/06) and seasonal fishing ban, that in southern Adriatic has been mandatory since the late eighties.

In 2008 a management plan was adopted, that foresaw the reduction of fleet capacity associated with a reduction of the time at sea. Two biological conservation zone (ZTB) were permanently established in 2009 (Decree of Ministry of Agriculture, Food and Forestry Policy of 22.01.2009; GU n. 37 of 14.02.2009) along the mainland, offshore Bari (180 km2, between about 100 and 180 m depth), and in the vicinity of Tremiti Islands (115 km2 along the bathymetry of 100 m) on the northern border of the GSA where a marine protected area (MPA) had been established in 1989. In the former only the professional small scale fishery using fixed nets and long-lines is allowed, from January 1st to June 30th, while in the latter the trawling fishery is allowed from November 1st to March 31 and the small scale fishery all year round. Recreational fishery using no more than 5 hooks is allowed in both the areas. Since June 2010 the rules implemented in the EU regulation (EC 1967/06) regarding the cod-end mesh size and the operative distance of fishing from the coasts are enforced.

In Montenegro, management regulations are based on technical regulations, such as mesh size (Official Gazette of Montenegro, 8/2011), including the minimum landing sizes (Official Gazette of Montenegro, 8/2011), and a regulated number of fishing licenses and area limitation (no–fishing zone up to 3 NM from the coastline or 8 NM for trawlers of >24 m LOA). Currently there are no MPAs or fishing bans in Montenegrin waters.

In Albania, a new law “On fishery” has now been approved, repealing the Law n. 7908. The new law is based on the main principles of the CFP, it reflects Reg. 1224/2009 CE ; Reg.1005/2008 CE; Reg. 2371/2002 CE; Reg. 1198/2006 CE; Reg. 1967/2006 CE; Reg. 104/2000; Reg. 1543/2000. Also concerning conservation and management measures, minimum legal sizes and minimum mesh sizes are those proposed by EU Regulations.

5.2.8.1.3 Landings

Total landings available to EWG 15-16 covered the period 2006-2014 (Table 5.2.8.5.3.1).

Table 5.2.8.5.3.1. Spot-tail mantis shrimp in GSA 18. Total landings by fishing gear in the period 2007-2014.

Gear	2006	2007	2008	2009	2010	2011	2012	2013	2014
GNS	160.9	87.92	51.93	54.14	19.08	44.27	16.94	44.98	0.47
GTR	25.8	12.59	31.00	18.13	19.17	19.42	19.90		4.25
OTB	1076	1157.94	833.89	820.10	415.81	288.58	594.84	2150.95	999.17
Other	9.24								
Total	1271.9	1258.46	916.82	892.37	454.05	352.27	631.68	2195.94	1003.89

5.2.8.1.4 Discards

Discards data were available to EWG 15-16 for the period 2009-2014 (Table 5.2.8.5.4.1). Discards for 2007 and 2008 were reconstructed based on the average discards in 2009-2011.

Table 5.2.8.5.4.1. Spot-tail mantis shrimp in GSA 18. Total discards by fishing gear in the period 2009-2014.

Gear	2007	2008	2009	2010	2011	2012	2013	2014
GNS					1.19	0.64	2.86	
GTR					0.00			
OTB	82	82	90.91	93.17	60.77	268.67	423.55	78.71
Total	82*	82*	90.91	93.17	61.95	269.30	426.41	78.71

*reconstructed

5.2.8.1.5 Fishing effort

Available DCF data show a steep decline in nominal fishing effort (engine kw*days) for bottom otter trawlers operating in GSA 18 (Figure 5.2.8.5.5.1 and Table 5.2.8.5.5.1).

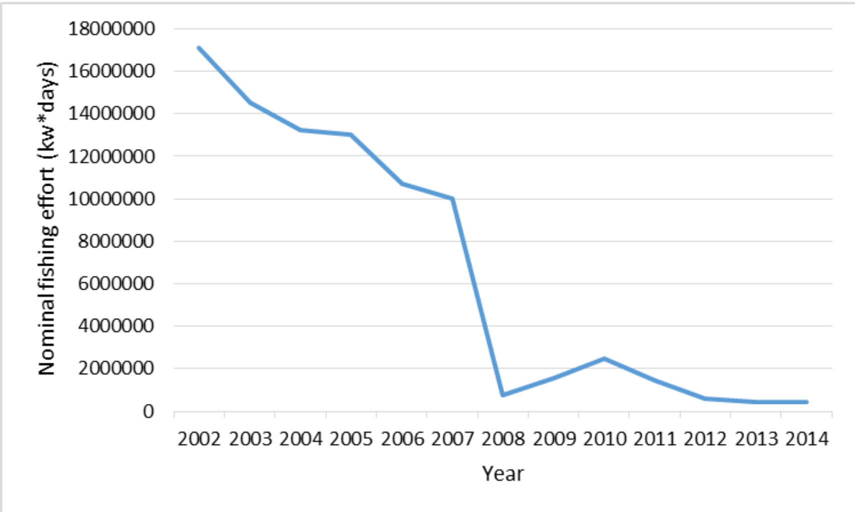


Figure 5.2.8.5.5.1. Fishing effort in GSA 18. Trends in annual bottom otter trawler nominal fishing effort (kw*days) in GSA 18 from 2002 to 2014.

Table 5.2.8.5.5.1. Fishing effort in GSA 18. Annual nominal fishing effort (kW*days) in GSA 18 from 2002 to 2014 as reported through the DCF official data call. Fishery codes: -1 – no information; DWSP – deep water species; MDDWSP – mixed demersal and deep water species.

	Fishery	

Year	Gear	-1	DWSP	MDDWSP	Total
2002	OTB	17112022			17112022
2003	OTB	14530793			14530793
2004	OTB			13241221	13241221
2005	OTB			13024315	13024315
2006	OTB			10702114	10702114
2007	OTB			10017537	10017537
2008	OTB		130964	609325	740289
2009	OTB		108546	1478134	1586680
2010	OTB		124777	2344855	2469632
2011	OTB		46554	1399545	1446099
2012	OTB			596064	596064
2013	OTB			424108	424108
2014	OTB			449344	449344

Table 5.2.8.5.5.2. Fishing effort in GSA 18. Annual fishing effort (GT*days at sea) in GSA 18 from 2002 to 2014 as reported through the DCF official data call. Fishery codes: -1 – no information; DWSP – deep water species; MDDWSP – mixed demersal and deep water species.

		Fishery			
Year	Gear	-1	DWSP	MDDWSP	Total
2002	OTB	-1			-1
2003	OTB	-1			-1
2004	OTB			2356478	2356478
2005	OTB			2298474	2298474
2006	OTB			2058309	2058309
2007	OTB			1772419	1772419
2008	OTB		29701	119323	149024
2009	OTB		18235	266753	284988
2010	OTB		21524	437823	459347
2011	OTB		10809	281989	292798
2012	OTB			132377	132377
2013	OTB			94784	94784
2014	OTB			80351	80351

Scientific surveys

5.2.8.1.6 Survey #1 (MEDITS)

5.2.8.1.6.1 Methods

According to the MEDITS protocol (Bertrand et al., 2002), trawl surveys were yearly (May-July) carried out, applying a random stratified sampling by depth (5 strata with depth limits at: 50, 100, 200, 500 and 800 m; each haul position randomly selected in small sub-areas and maintained fixed throughout the time). Haul allocation was proportional to the stratum area. The same gear (GOC 73, by P.Y. Dremière, IFREMER-Sète), with a 20 mm stretched mesh size in the cod-end, was employed throughout the years. Detailed data on the gear characteristics, operational parameters and performance are reported in Dremière and Fiorentini (1996). Considering the small mesh size a complete retention was assumed. All the abundance data (number of fish per surface unit) were standardized to square kilometer, using the swept area method.

In GSA 18 the following number of hauls was reported per depth stratum (Table 5.2.8.6.1.1.1).

Table 5.2.8.6.1.1.1. Number of hauls per year and depth stratum in GSA 18, 1994-2013.

	YEAR										
Stratum	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
10-50	14	14	18	17	17	17	17	18	12	12	11
51-100	14	15	24	25	25	26	25	24	20	19	21
101-200	24	23	32	33	33	32	33	33	31	32	31
201-500	10	10	19	18	18	19	18	18	13	13	13
501-800	10	10	19	19	19	18	19	19	14	14	14
Total	72	72	112	112	112	112	112	112	90	90	90
	YEAR										
Stratum	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	
10-50	11	11	11	12	12	12	12	12	12	12	
51-100	20	21	20	22	20	20	20	20	20	20	
101-200	32	31	32	33	30	31	31	31	31	31	
201-500	13	13	13	12	14	13	13	13	13	13	
501-800	14	14	14	11	14	14	14	14	14	14	
Total	90	90	90	90	90	90	90	90	90	90	

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Catches by haul were standardized to 60 minutes hauling duration.
Hauls noted as valid were used only, including stations with no catches of hake, red mullet or pink shrimp (zero catches are included). The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in the GSA: $Yst = S (Yi*Ai) / A$

$V(Yst) = S (Ai^2 * si^2 / ni) / A^2$
Where:
A=total survey area
Ai=area of the i-th stratum
si=standard deviation of the i-th stratum
ni=number of valid hauls of the i-th stratum
n=number of hauls in the GSA
Yi=mean of the i-th stratum
Yst=stratified mean abundance
V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as ± standard deviation.

Length distributions represented an aggregation (sum) of standardized length frequencies distribution raised to standardized haul abundance per square km over the stations of each stratum.

5.2.8.1.6.2 Geographical distribution

Mantis shrimp is distributed on sandy-muddy bottoms, mostly within 50 m depth. No information on the spatial distribution of the population is available.

5.2.8.1.6.3 Trends in abundance and biomass

Fishery independent information regarding the state of the mantis shrimp in GSA 18 was obtained from the international survey MEDITS. Figure 5.2.8.6.1.3.1 shows the estimated trend of mantis shrimp abundance and biomass per square km. Both indices show a highly variable pattern due to the fluctuaction in recruitment with main peaks in 2004, 2006 and 2012.

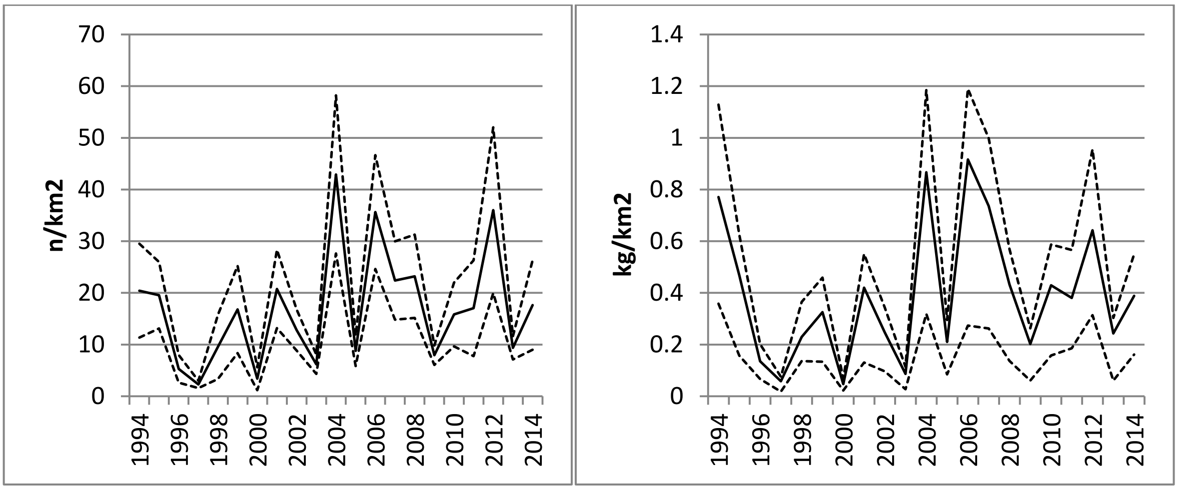


Figure 5.2.8.6.1.3.1. Spot-tail mantis shrimp in GSA 18. Abundance (n/km^2) and biomass (kg/km^2) indices with standard deviation intervals estimated from the MEDITS data for the period 1994 to 2014.

5.2.8.1.6.4 Trends in abundance by length or age

Collection of length data of mantis shirmp during MEDITS started in 2012. Length frequency distributions are therefore available for 2012-2014 only (Fig. 5.2.8.6.1.4.1).

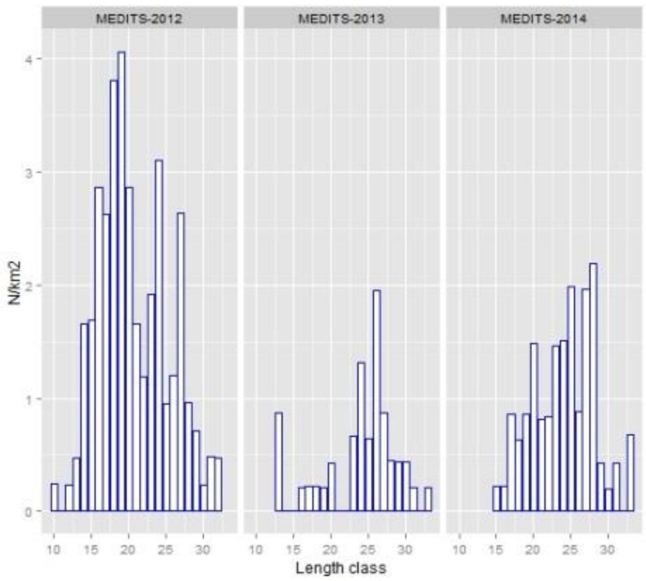


Figure 5.2.8.6.1.4.1. Spot-tail mantis shrimp in GSA 18. Stratified abundance indices by size estimated from the MEDITS survey data for the years 2012 - 2014.

Stock Assessment

5.2.8.1.7 Method: XSA

The stock was assessed through XSA, using FLR libraries and input data over the period 2007-2014.

5.2.8.1.8 Input data

Catch and catch numbers at age input data were available only for the Italian side of GSA 18 (Fig. 5.2.8.7.2.1). MEDITS data covering the years 2012-2014 for the whole GSA were used as tuning data after having been transformed in age distributions by means of a knife-edge age slicing procedure using the software LFDA 5.0. Table 5.2.8.7.2.1 lists input data used for the assessment.

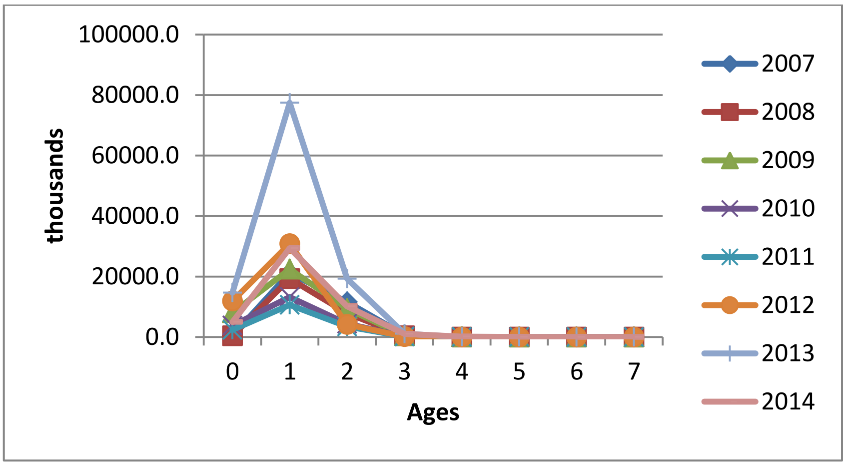


Figure 5.2.8.7.2.1. Spot-tail mantis shrimp in GSAs 18. Catch at age by year.

Table 5.2.8.7.2.1. Spot-tail mantis shrimp in GSA 18. List of the XSA input data: landings, catch numbers at age, weight at age, maturity-at-age.

Catch (t)

2007	2008	2009	2010	2011	2012	2013	2014
1459.8	1063.5	983.3	547.2	414.2	901.0	2622.3	1082.6

Catch number at age (thousands)

	2007	2008	2009	2010	2011	2012	2013	2014
0	504.4	423.8	8056.6	3822.8	2388.1	11889.5	14677.6	4984.4
1	21168.8	19318.8	22438.4	13241.3	10656.8	30859.3	77478.2	29364.2
2	11589.9	7850.1	9364.7	4385.3	3466.8	4188.2	19287.7	10142.1
3	695.4	420.3	452.0	267.4	156.0	136.2	1107.0	1039.8
4	28.9	10.5	39.5	11.1	16.8	10.5	64.1	152.8
5	0.0	0.9	0.0	4.3	19.5	4.4	14.2	29.5
6	0.0	4.7	0.0	0.1	0.2	0.0	0.1	0.4
7	0.0	1.4	0.0	0.0	0.0	0.0	0.0	4.7

Weight at age in the catch and in the stock (kg)

	2007	2008	2009	2010	2011	2012	2013	2014
0	0.01	0.01	0.0064	0.008	0.01	0.01	0.01	0.0075
1	0.027	0.026	0.024	0.022	0.023	0.021	0.024	0.02
2	0.049	0.045	0.045	0.047	0.044	0.044	0.042	0.04
3	0.073	0.066	0.067	0.071	0.068	0.067	0.058	0.06
4	0.094	0.084	0.085	0.09	0.089	0.091	0.07	0.075
5	0.095	0.095	0.1	0.1	0.1	0.1	0.08	0.09
6	0.1	0.1	0.1	0.11	0.1	0.1	0.08	0.09
7	0.12	0.12	0.12	0.12	0.12	0.12	0.11	0.11

Maturity at age

	2007	2008	2009	2010	2011	2012	2013	2014
0	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
1	0.809	0.809	0.809	0.809	0.809	0.809	0.809	0.809
2	1	1	1	1	1	1	1	1
3	1	1	1	1	1	1	1	1
4	1	1	1	1	1	1	1	1
5	1	1	1	1	1	1	1	1
6	1	1	1	1	1	1	1	1
7	1	1	1	1	1	1	1	1

5.2.8.1.9 Results

A sensitivity analysis was run considering different XSA settings: rage (0-3) and qage (1-3). The effect of different shrinkage ages (shk.age: 1,2,3) was then evauated based on the settings that looked more stable and with lower residuals. Comparison in Fbar, SSB and recruitment, between settings shows minor differences in estimates and a common trend (Fig. 5.2.8.7.3.1). Finally, values ranging from 0.5 to 2 (0.5 increasing) for the shrinkage weight have been tested. Both the residuals and retrospective analysis were used to choose the best model.

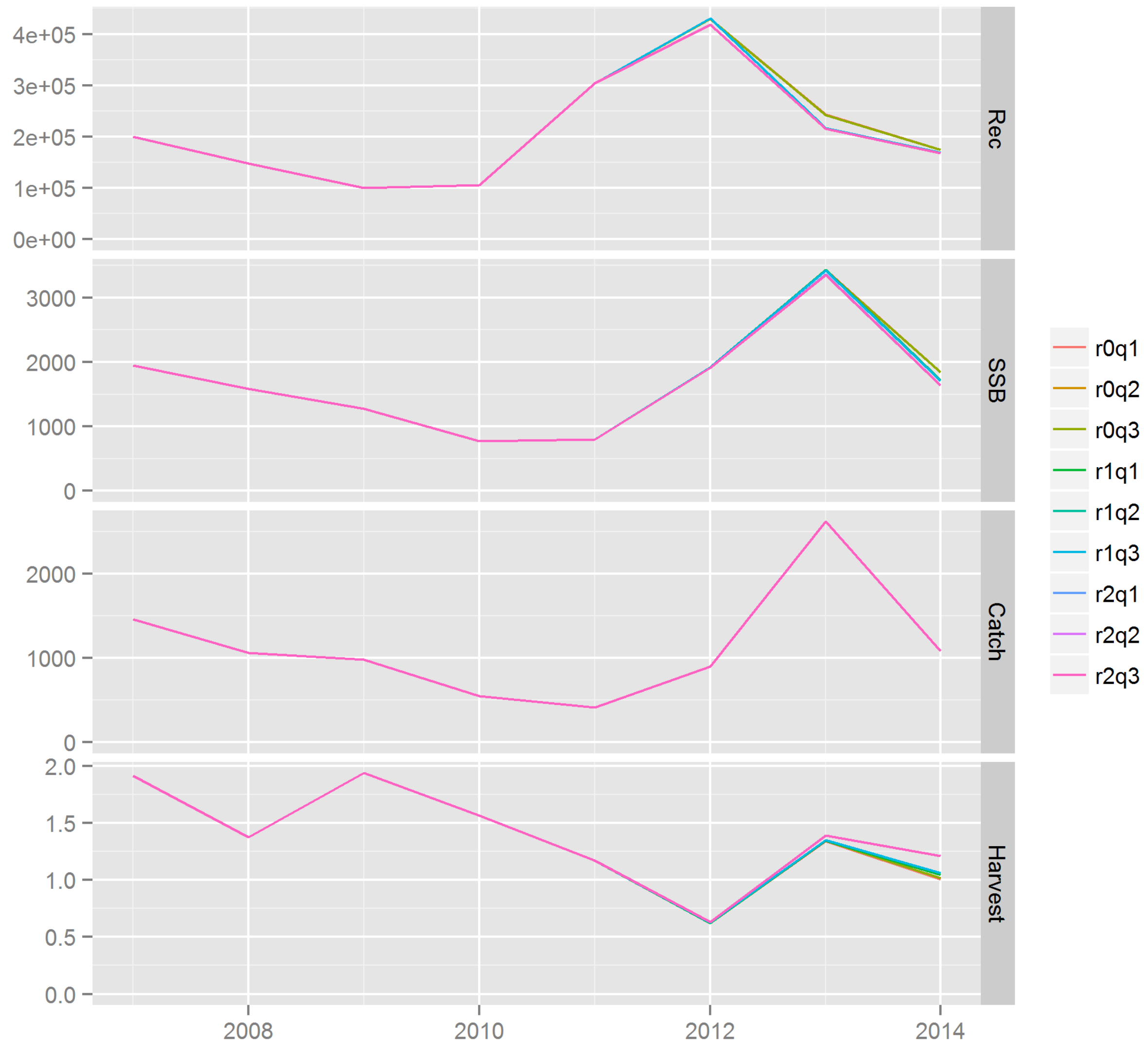


Figure 5.2.8.7.3.1. Spot-tail mantis shrimp in GSA 18. Results of the sensitivity analysis performed on rage and qage.

The lowest residuals were obtained with the following settings: rage=1,qage=2, shk.age=3, fse=1.0 (model 7, table 5.2.8.7.3.1, figure 5.2.8.7.3.2). The retrospective analysis was influenced by the short time series of tuning data (3 years). However both models 7 and 12 returned a consistent pattern (figure 5.2.8.7.3.3).

Table 5.2.8.7.3.1. Spot-tail mantis shrimp in GSA 18. Residuals of the three best models obtained.

model 7: rage =1, qage=2, shk.age=3, fse=1

age	2012	2013	2014
0	0.536254	-0.41718	-0.1198
1	0.000162	-0.00034	0.00018
2	0.416467	-0.79033	0.373865

model 12: rage=1, qage=2, shk.age= 3, fse=1

age	2012	2013	2014
0	0.82817	-0.64398	-0.18466
1	0.38634	-0.7992	0.42791
2	0.4179	-0.79192	0.37402

model 5: rage=0, qage=2, shk.age=3, fse=1

age	2012	2013	2014
0	0.70112	-0.57954	-0.14256
1	0.43702	-0.73677	0.29975
2	0.40849	-0.79732	0.38883

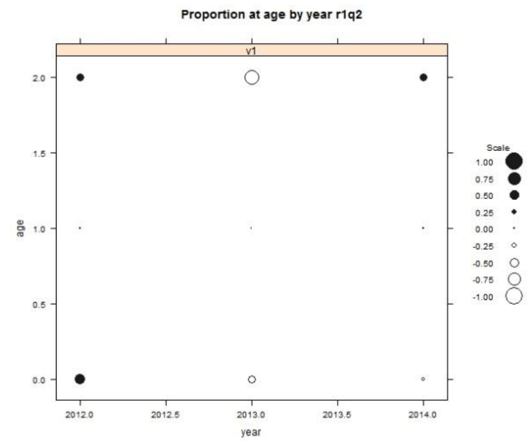


Figure 5.2.8.7.3.2. Spot-tail mantis shrimp in GSA 18. XSA residuals for MEDITS survey for model 7 (see table 5.2.8.7.3.1).

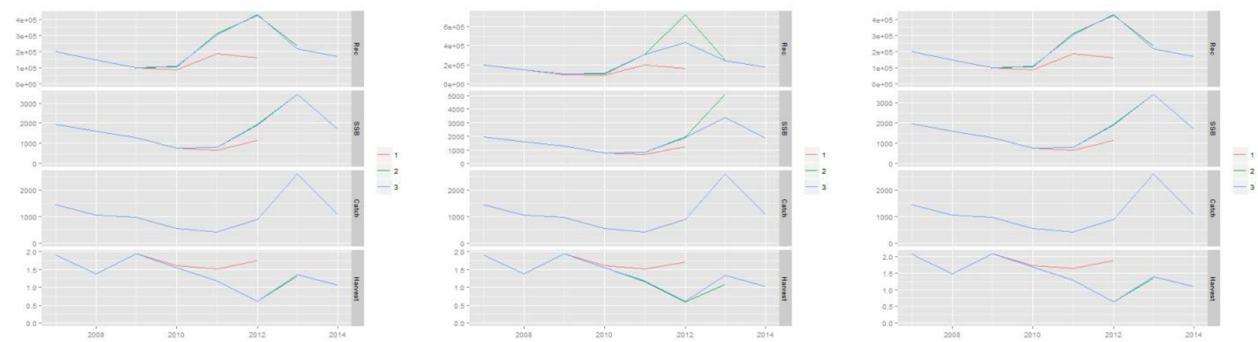


Figure 5.2.8.7.3.3. Spot-tail mantis shrimp in GSA 18. XSA retrospective analysis for the three best models. From the left: model 7, model 5, model 12 (see table 5.2.8.7.3.1).

Model 7 was therefore selected as final model, based on residuals and retrospective analysis The setting that minimized residuals and showed a consistent retrospective analysis were those of model 7: : fse=1.0, rage=1, qage=2, shk.yrs=3 (Fig. 5.2.8.7.3.2 and Fig. 5.2.8.7.3.3).

XSA results show a peak in SSB in 2013 at about 3500 tons followed by a reduction in 2014 (1600 tons). Recruiment shows a peak in 2012 at about 430 millions. F_{0-4} shows a declining trend since 2007 with F_{0-4} =1.0 in 2014 (Fig. 5.2.8.7.3.4).

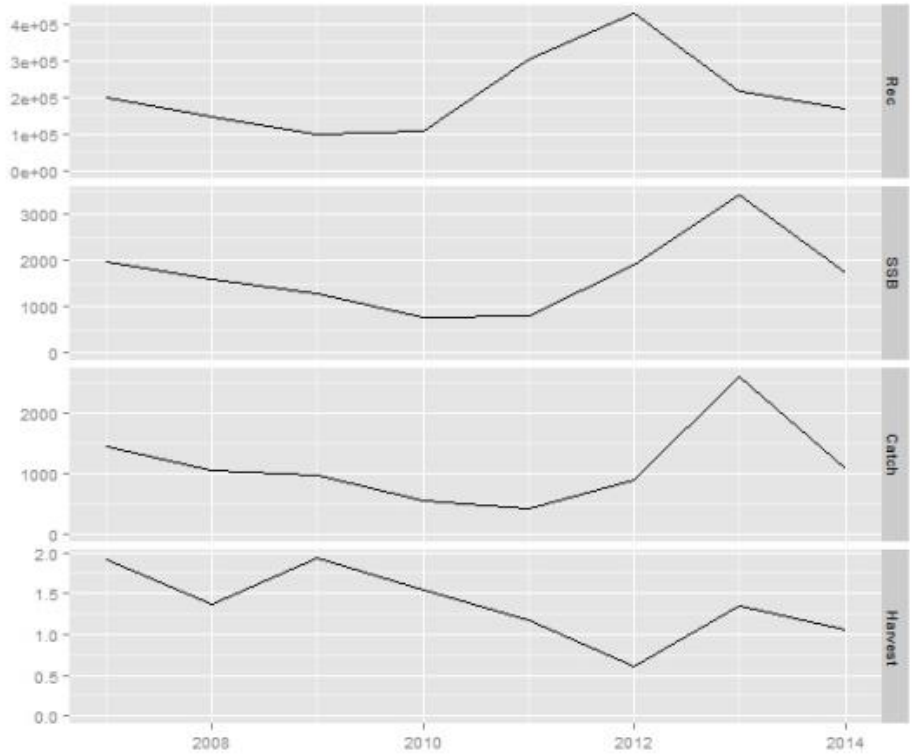


Figure 5.2.8.7.3.4. Spot-tail mantis shrimp in GSA 18. XSA summary results. SSB and catch are in tonnes, recruitment in 1000s individuals, harvest is F_{0-4}.

The XSA stock estimates of mantis shrimp in GSA 18 are showed in tables 5.2.8.7.3.2-5.2.8.7.3.4.

Table 5.2.8.7.3.2. Spot-tail mantis shrimp in GSA 18. Stock numbers at age as estimated by XSA.

age	2007	2008	2009	2010	2011	2012	2013	2014
0	199100	143700	100730	106480	310840	420260	215810	168360
1	54275	52842	38066	26385	30147	92433	120690	57904
2	13661	9838	11272	5047	4648	8118	26041	13337
3	723	530	522	362	65	328	1650	2102
4	33	14	48	14	31	23	98	240
5+	4	12	0	6	30	27	20	54

Table 5.2.8.7.3.3. Spot-tail mantis shrimp in GSA 18. Fishing mortality at age as estimated by XSA.

age	2007	2008	2009	2010	2011	2012	2013	2014
0	0.13	0.13	0.14	0.06	0.01	0.05	0.11	0.05
1	1.01	0.85	1.26	1.04	0.61	0.58	1.43	0.99
2	2.65	2.33	2.86	2.62	2.06	0.99	2.12	1.64
3	3.39	1.87	3.03	2.11	1.73	0.70	1.41	1.30
4	2.35	1.68	2.38	1.92	1.47	0.76	1.65	1.30
5+	2.35	1.68	2.38	1.92	1.47	0.76	1.65	1.30

Table 5.2.8.7.3.4. Spot-tail mantis shrimp in GSA 18. Fishing mortality (F_{0-4}), spawning stock biomass and recruitment as estimated by XSA.

age	2007	2008	2009	2010	2011	2012	2013	2014
$F_{0\text{-}4}$	1.91	1.37	1.94	1.55	1.17	0.62	1.35	1.05
SSB	1961.63	1596.34	1256.1	752.86	796.67	1952.83	3415.16	1682.55
Recruitment (million)	198.9	147.0	100.7	106.5	303.9	430.3	216.9	169.2

Reference points

5.2.8.1.10 Methods

The XSA package used allowed a yield per recruit analysis and an estimate of some equilibrium Reference Points such as F_{max} and $F_{0.1}$. Yield per recruit computation was made by R project software and the FLR libraries. The fishing mortality rate corresponding to $F_{0.1}$ in the yield per recruit curve was considered as a proxy of $F_{MSY.}$

5.2.8.1.11 Input data

The input parameters were the same used for the XSA stock assessment and its results.

5.2.8.1.12 Results

The yield per recruitment curve for spot-tail mantis shrimp in GSA 18 is showed in fig. 5.2.8.8.3.1.

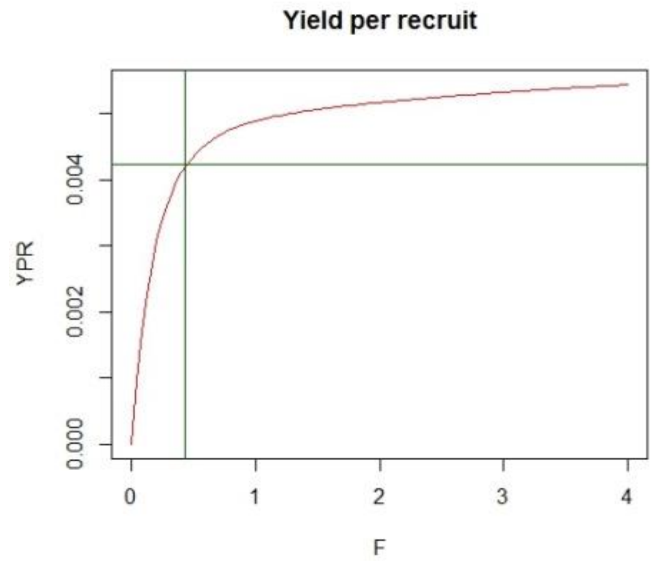


Figure 5.2.8.8.3.1. Spot-tail mantis shrimp in GSA 18. Yield per recruit curve showing the position of the estimated F_{01} =0.43.

Data quality

The assessment was based on the EU DCF data (landings and discards) collected by Italy in the western part of GSA 18. Data from Albania and Montenegro were not available during EWG 15-16. Italian annual landings data were available since 2006 wherease size/age structures of the landings covered the period 2007-2014. Discards data were not available before 2008 and were reconstructd during EWG 15-16 using the mean proportion of discard observed in 2008-2010. The size/age structure of landing and discards was not available for gillnets and trammel nets in the years 2007 and 2008. The age structure of these two years was reconstructed using the reported landings/discards and the average age structure of the catch of the two gear reported for the years 2010-2014. The impact of such reconstructed data on the assessment results can be considered however negligible considering that the contribution of the gillnets and trammel nets catch over the total annual landing was less than 10% in most of the years.

Short term predictions 2015-2017

5.2.8.1.13 Method

A deterministic short term prediction for the period 2015 to 2017 was performed using the FLR routines provided by JRC and based on the results of the XSA stock assessments performed during EWG 15-16.

5.2.8.1.14 Input parameters

Input parameters were the same used for the XSA stock assessment. An average of the last three years has been used for weight at age, maturity at age and F at age. Recruitment (age 0) has been estimated from the population results as the geometric mean of the last 3 years (250 million specimens).

5.2.8.1.15 Results

A short term projection (Table 5.2.8.10.3.1), assuming an F_{stq} of 0.96 (as a geometric average 2012-2014) in 2015 and a recruitment of 250 million individuals shows that:

- Fishing at the F_{stq} (0.95) generates an increase of the catch of 1.3% from 2014 to 2016 along with an increase of the spawning stock biomass of 9.5% from 2016 to 2017.
- Fishing at $F_{0.1}$ (0.43) generates a decrease of the catch of 43.1% from 2014 to 2016 and an increase of the spawning stock biomass of 40.9% from 2016 to 2017.

Table 5.2.8.10.3.1. Spot-tail mantis shrimp in GSA 18. Short term forecast in different F scenarios Basis: F(2015) = geometric mean (F_{bar} 0-4+ 2012-2014)= 0.95; R(2015) = geometric mean of the recruitment of the last 3 years; R = 250 million; SSB(2014) = 1714 t, Catch (2014)= 1082.6 t.

Rationale	Ffactor	Fbar	Catch 2014	Catch 2015	Catch 2016	Catch 2017	SSB 2016	SSB 2017	Change SSB 2016 - 2017(%)	Change catch 2014 - 2016(%)
0 catch	0	0	1082.6	918.5	0	0	1743.4	3200.4	83.9	-100
High long term yield (F01)	0.46	0.43	1082.6	918.5	615.5	879.5	1743.4	2456.4	40.9	-43.1
Status quo	1	0.95	1082.6	918.5	1097.1	1201.9	1743.4	1908.5	9.5	1.3
Scenarios	0.1	0.09	1082.6	918.5	159.0	285.1	1743.4	3004.9	72.4	-85.3
	0.2	0.19	1082.6	918.5	303.7	508.3	1743.4	2828.7	62.2	-71.9
	0.3	0.28	1082.6	918.5	435.8	683.1	1743.4	2669.7	53.1	-59.7
	0.4	0.38	1082.6	918.5	556.4	819.9	1743.4	2526.2	44.9	-48.6
	0.5	0.47	1082.6	918.5	666.7	927.2	1743.4	2396.4	37.5	-38.4
	0.6	0.57	1082.6	918.5	767.9	1011.3	1743.4	2278.9	30.7	-29.1

	0.7	0.66	1082.6	918.5	860.7	1077.2	1743.4	2172.4	24.6	-20.5
	0.8	0.75	1082.6	918.5	946.0	1129.0	1743.4	2075.9	19.1	-12.6
	0.9	0.85	1082.6	918.5	1024.6	1169.8	1743.4	1988.2	14.0	-5.4
	1.1	1.04	1082.6	918.5	1164.1	1227.4	1743.4	1835.9	5.3	7.5
	1.2	1.13	1082.6	918.5	1226.1	1247.6	1743.4	1769.7	1.5	13.3
	1.3	1.23	1082.6	918.5	1283.6	1263.8	1743.4	1709.3	-2.0	18.6
	1.4	1.32	1082.6	918.5	1337.0	1276.8	1743.4	1654.1	-5.1	23.5
	1.5	1.42	1082.6	918.5	1386.6	1287.4	1743.4	1603.5	-8.0	28.1
	1.6	1.51	1082.6	918.5	1432.9	1296.0	1743.4	1557.2	-10.7	32.4
	1.7	1.60	1082.6	918.5	1476.2	1303.3	1743.4	1514.6	-13.1	36.4
	1.8	1.70	1082.6	918.5	1516.7	1309.4	1743.4	1475.5	-15.4	40.1
	1.9	1.79	1082.6	918.5	1554.6	1314.6	1743.4	1439.4	-17.4	43.6
	2	1.89	1082.6	918.5	1590.2	1319.1	1743.4	1406.1	-19.3	46.9

Short term predictions 2015-2017 by fleet

5.2.8.1.16 Method

A deterministic short term prediction by fleet for the period 2015 to 2017 was performed using the FLR routines provided by JRC and based on the results of the XSA stock assessments performed during EWG 15-16. Two fleets were considered: trawlers and small-scale vessels using fixed nets (gillnets and trammel-nets).

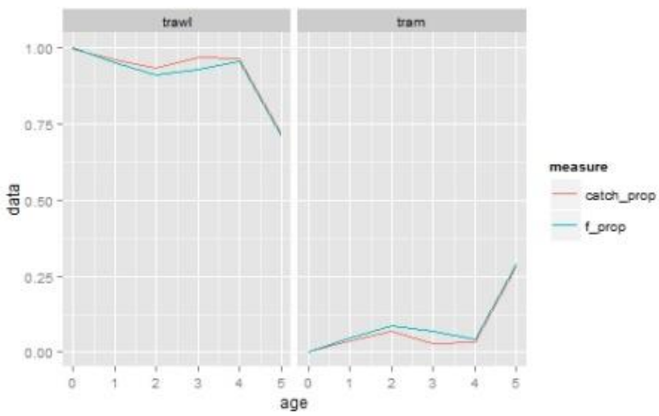
5.2.8.1.17 Input parameters

The same parameters used in the short term by single fleet were used.

5.2.8.1.18 Results

The main results of the short term predictions by fleet are shown in Table 5.2.8.11.3.1 and Figure 5.2.8.11.3.1.

Catch/fishing mortality proportion by fleet (trawl: left; fixed nets: right)



Fishing mortality scenarios by fleet

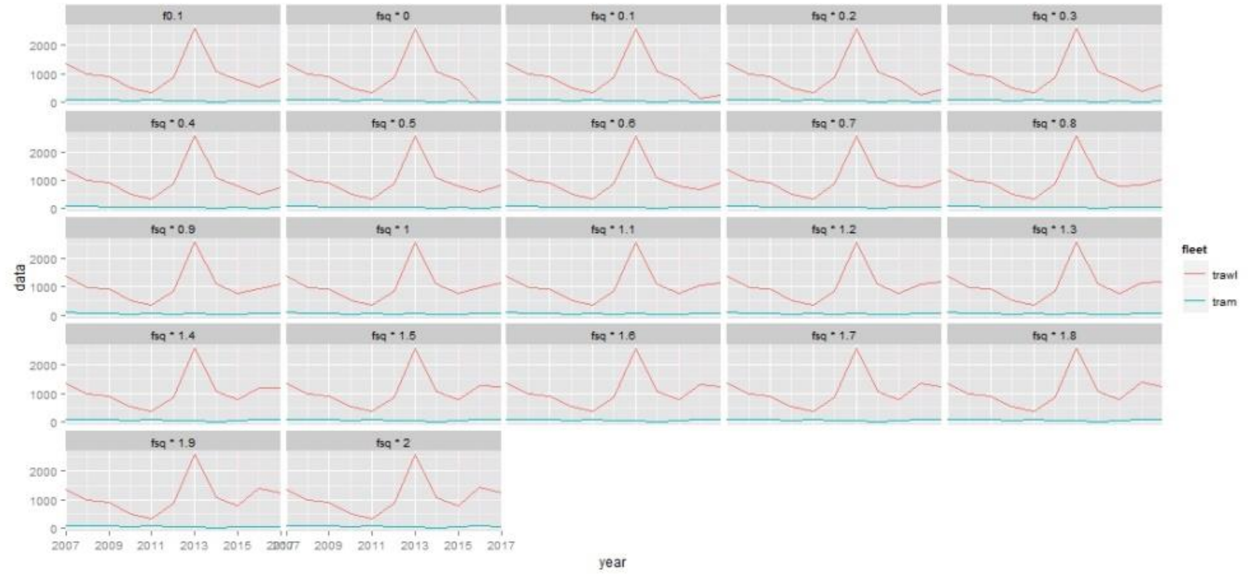


Figure 5.2.8.11.3.1. Spot-tail mantis shrimp in GSA 18. Selectivity by fleet, catch/fishing mortality proportion by fleet, catches by fleet for different fishing mortality scenarios.

Table 5.2.8.11.3.1. Spot-tail mantis shrimp in GSA 18. Short term forecast by fleet and GSA at current F (Fsq) and F_{MSY} ($F_{0.1}$).

fleet	year	catches	F scenario	partial_f
OTB	2016	1056.3	Fsq	0.9
OTB		591.6	F0.1	0.41
GTR-GNS		40.8	Fsq	0.05
GTR-GNS		23.9	F0.1	0.02
OTB	2017	1154.0	Fsq	0.9
OTB		842.3	F0.1	0.41
GTR-GNS		47.9	Fsq	0.05
GTR-GNS		37.2	F0.1	0.02

Following the agreement reached during the discussions of the EWG-12-19, medium term prediction would only be performed if there is a reliably fit of a stock-recruitment relationship. In the case of Spot-tail mantis shrimp in GSA 18, the time-series available (2007-2014) is too short to derive any reliable relationships between recruits and SSB and therefore no medium term predictions were made (Figure 5.2.8.11.3.2).

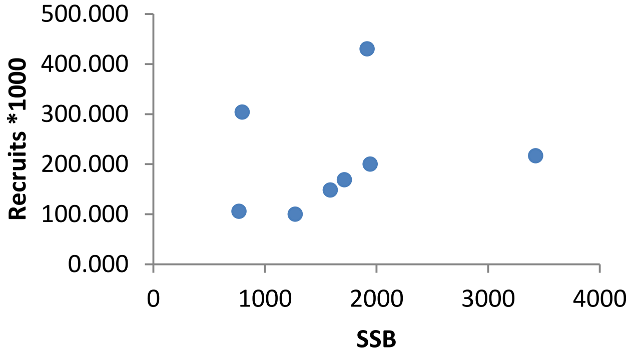


Figure 5.2.8.11.3.2. Spot-tail mantis shrimp in GSA 18. Spawning stock biomass (SSB) and recruitment (R) relationship.

5.2.8.1.19 Method

Stock advice

The current F_{0-5} (1.05) is larger than F_{MSY} (0.43), which indicates that mantis shrimp is being fished above F_{MSY}. STECF EWG 15-16 recommends the relevant fleets' cacthes and/or effort to be reduced until fishing mortality is below or at the proposed F_{MSY} level, in order to avoid future loss in stock productivity and landings. This should be achieved by means of a multi-annual management plan taking into account mixed-fisheries considerations. Catches of mantis shrimp in GSA 18 in 2016 consistent with F_{MSY} should not exceed 615 t.

Management strategy evaluation

The Management Strategy Evaluation to evaluate if the F_{MSY} ranges are precautionary was run using R script provided during by STECF 15-16. F ranges results were F_{upper}= 0.59 and F_{lower}= 0.29. B_{lim} was estimated in 848 t (Fig. 5.2.8.13.1).

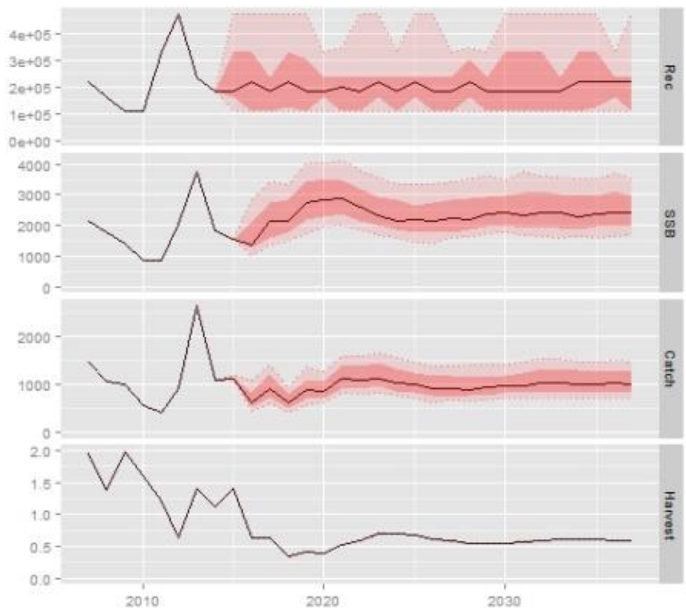


Figure 5.2.8.13.1. Spot-tail mantis shrimp in GSA 18. Marine Strategy Evaluation.

The probability of SSB to fall below B_{lim} at $F = F_{upper}$ is equal to 0.

5.2.9 STOCK ASSESSMENT OF SPOT-TAIL MANTIS SHRIMP IN GSA 17-18

Stock Identification

The spot-tail mantis shrimp is found in the Mediterranean and in the adjacent eastern Atlantic ocean, from the Gulf of Cadiz to Angola. It is found from sublittoral depths on sandy and muddy bottoms to around 150 m depth (Abelló et al., 2002). There is not a clear distribution pattern by size and depth; however, juveniles are generally more abundant in waters shallower than 30 m depth (Abelló and Martín, 1993). In the Italian waters, it is found along the coasts of the whole peninsula, and is particularly abundant in the northern and central Adriatic Sea, where it ranks amongst the most relevant species exploited by commercial fisheries (Froglia, 2010).

The spot-tail mantis shrimp digs U-shaped burrows in which it hides during the day. It has threfore a preference for areas with suitable burrowing substrate, such as fine sand and sandy- muddy bottoms, especially where the influence of river sediment intakes is important (Froglia, 1996; Atkinson et al., 1997). In fact, it is very abundant on the continental shelves at the mouths of Ebro, Rhone, Po, and Nile rivers, as a matter of fact the species is very abundant in the western side of the Adriatic basin, while it is almost absent in the eastern side.

It is a strongly sedentary species and seasonal trends appearing in catch data are due more to its reproductive and burrowing behaviour, and recruitment pattern, than to temporal changes in its distribution (Maynou et al., 2004).

In the present assessment a combination of data coming from the two Adriatic GSAs (17 and 18) has been carried out.

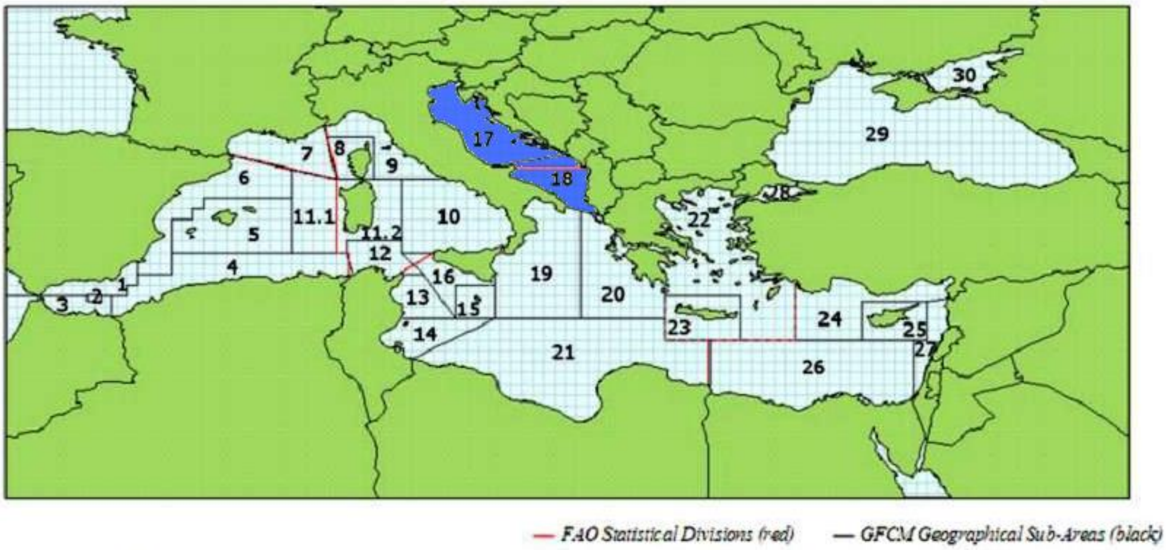


Figure 5.2.7.1.2. Geographical localization of GSA 17-18.

Growth

Growth parameters are those used in each GSA (see sections of GSA 17 and GSA 18 assessments).

Maturity

Maturity ogives were taken from each GSA (see sections of GSA 17 and GSA 18 assessments). Combined maturity at age were calculated as a weighted average using the stock numbers.

Natural mortality

Maturity ogives were taken from each GSA (see sections of GSA 17 and GSA 18 assessments). Combined maturity at age were calculated as a weighted average using the stock numbers.

Fisheries

5.2.9.1.1 General description of the fisheries

Spot-tail mantis shrimp is targeted mainly by bottom trawlers. See Chapters 5.2.7.5.1-5.2.8.5.1 in the Report for further details on spot-tail mantis shrimp fisheries in GSAs 17, and 18.

5.2.9.1.2 Management regulations applicable in 2015

See Chapters 5.2.7.5.2-5.2.8.5.2 in the Report for management regulations on spot-tail mantis shrimp fisheries in GSAs 18, and 19.

5.2.9.1.3 Catches

Landings and discards by fleet are described in the following sections 5.2.9.5.4 and 5.2.9.5.5.

5.2.9.1.4 Landings

The overall landings from GSA 17 and 18 shows show a general decrease from 2008 to 2014. The total trend and by GSAs are shown in table 5.2.8.5.4.1 and in figure 5.2.8.5.4.1.

Table 5.2.9.5.4.1. Spot-tail mantis shrimp in GSA 17-18. Landings (in tonnes) from 2006 to 2014.

	GSA 17	GSA 18	Total
2006		1271.9	
2007	3912	1258.46	5170.46
2008	4005	916.82	4921.82
2009	4533	892.37	5425.37
2010	4570	454.05	5024.05
2011	3790	352.27	4142.27
2012	3106	631.68	3737.68
2013	2128	2195.94	4323.94
2014	2806	1003.89	3809.89

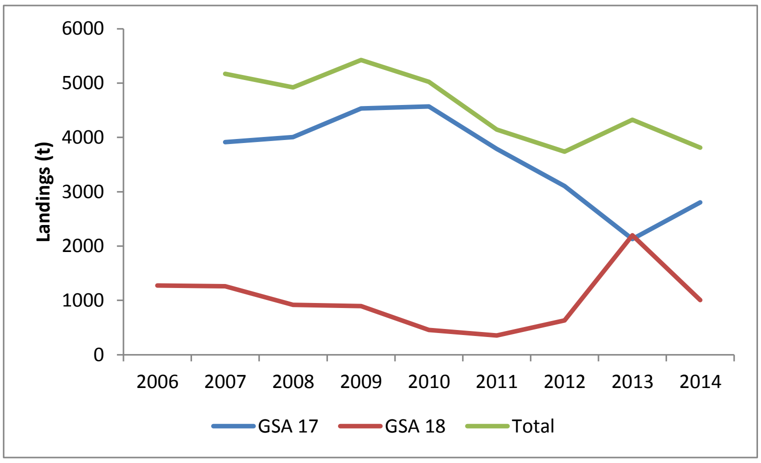


Figure 5.2.9.5.4.1. Spot-tail mantis shrimp in GSA 17-18. Trend in landings (in tonnes) from 2006 to 2014.

In table 5.2.7.5.4.1 the landings by gear are reported.

Table 5.2.7.5.4.1. Spot-tail mantis shrimp in GSA 17-18. Landings by fishing fleet and gear from 2005 to 2014.

		Slovenia									Italy				
GSA	**Year**	**FPO**	**FYK**	**GND**	**GNS**	**GTR**	**LLS**	**OTB**	**OTM**	**PS**	**GNS**	**OTB**	**TBB**	**GTR**	**Other**
17	2005	0.665			0.197	0.536	NA	3.164							
	2006	0.444			0.162	0.275	0.013	1.529							
	2007	0.317		0.003	0.352	0.503		6.069		0.001	936	2969			
	2008	0.446			0.867	1.193		3.717		0.002	831	2859	309		
	2009	0.284			0.493	0.617		2.21	0.025		872	3167	490		
	2010	0.416	0.003		0.339	0.995		3.241			961	3163	440		
	2011	0.775	0.002		0.184	0.417		2.210			1136	2399	251		
	2012	0.050	0.001		0.092	0.214	0.010	0.361			1141	1681	283		
	2013	0.048			0.045	0.094	0.004	0.111			205	1682	240		
	2014	0.027			0.021	0.120		0.31			296	2326	184		
18	2006										161	1076		26	9
	2007										88	1158		13	
	2008										52	834		31	
	2009										54	820		18	
	2010										19	416		19	
	2011										44	289		19	
	2012										17	595		20	
	2013										45	2151			
	2014										0	999		4	

5.2.9.1.5 Discards

Discards data were reported to STECF EWG 15-16 through the DCF. For more details on discards see sections 5.2.7.5.5-5.2.8.5.5 of this report. In table 5.2.9.5.4.1 the discards by gear are reported.

Table 5.2.9.5.5.1. Spot-tail mantis shrimp in GSA 17-18. Discard (in tonnes) for Italy and Slovenia by gear from 2005 to 2014.

		Slovenia			Italy		
GSA	**year**	**GNS**	**GTR**	**OTB**	**GNS**	**OTB**	**TBB**
17	2005	0.001	0.000	0.410			
	2006	0.000	0.000	0.125			
	2007	0.006	0.000	0.880			
	2008	0.038	0.000	0.506			
	2009	0.005	0.000	0.294			
	2010	0.000	0.001	0.438		375	
	2011	0.000	0.000	0.260	0.945	705	16.102
	2012	0.004	0.000	0.014		103	
	2013	0.000	0.000	0.001		258	
	2014	0.000	0.001	0.009		394	4.279
18	2007					82	

	2008					82	
	2009					90.91	
	2010					93.17	
	2011				1.19	60.77	
	2012				0.64	268.67	
	2013				2.86	423.55	
	2014					78.71	
	2007					82	

5.2.9.1.6 Fishing effort

Fishing effort data were reported to STECF EWG 15-16 through DCF. For more details on fishing effort, please see sections 5.2.7.5.6-5.2.8.5.6 in this report.

Scientific surveys

5.2.9.1.7 Survey #1 (SOLEMON) – GSA 17

Abundance and biomass indices were calculated for GSA 17 using Atris database (Gramolini et al., 2015). The data coming from SOLEMON surveys are presented in sections 5.2.7.6 of this report

5.2.9.1.8 Survey #2 (MEDITS)

Based on the DCF data call, abundance and biomass indices were calculated for GSA 17 and 18 using the ad hoc script prepared during the STECF EWG 15-06. The data coming from MEDITS surveys are presented in sections 5.2.7.6.2-5.2.8.6.1 of this report.
MEDITS survey was deemed inappropriate to be used as tuning index of Spot-tail mantis shrimp in GSA17 (see section 5.2.7.6.2). Moreover the use of MEDITS survey indexes from GSA 18 were not used in the present assessment because of the high residuals observed in the XSA diagnostics.

Stock Assessment

During EWG 15-16 the stock assessment was performed over the period 2008-2014. The SOLEMON *rapido* trawl survey was used as tuning index of the assessment and the age range used goes from 0 to 4, considering that older age classes are not so well represented.

5.2.9.1.9 Method

FLR libraries were employed in order to carry out an XSA based assessment. The spot-tail mantis shrimp stock in GSAs 17-18 was assessed for the first time. XSA was carried out using as input data the period 2008-2014 both for the catch data and for the tuning file.

5.2.9.1.10 Input data

Total catches and catch numbers at age from the single GSAs were used as input data. The R script prepared by JRC was used to create a combined stock object to be used in the assessment. Natural mortality and maturity were estimated as weighted mean by the catch numbers from the parameters used in the assessments of the single GSAs (Tables 5.2.9.7.2.1). MEDITS data for GSA 18 have not be used because of the high residuals observed in exploratory analyses (as example see Figure 5.2.9.7.2.1).

Table 5.2.9.7.2.1. Spot-tail mantis shrimp in GSA17-18. Input data to the XSA model.

Totola catches **2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	
5472.7	5979.4	5490	4924.4	4108.4	5006.3	4287.9	
Catch number (x 1000) **Age**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
0	11416	9240	4046	10379	11454	13905	4718
1	35292	75469	43289	67663	48362	81413	45458
2	46950	72454	71727	58363	47293	50572	52963
3	18253	17500	13644	11941	13041	12688	12740
4	8291	2744	5248	1011	2440	2007	3001
5	4028	353	2088	108	577	301	962
6	2387	141	1080	39	170	148	246
7+	2110	0	446	0	111	100	277
Weights-at-age in the catch and in the stock (kg) **Age**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
0	0.011	0.007	0.008	0.008	0.008	0.010	0.007
1	0.026	0.023	0.026	0.026	0.023	0.023	0.023
2	0.041	0.040	0.039	0.040	0.040	0.040	0.040
3	0.060	0.060	0.060	0.059	0.059	0.059	0.059
4	0.075	0.075	0.075	0.075	0.074	0.074	0.074
5	0.085	0.085	0.085	0.087	0.084	0.084	0.084
6	0.093	0.093	0.093	0.093	0.093	0.093	0.093
7+	0.110	0.106	0.105	0.106	0.107	0.100	0.102
Natural mortality **Age**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
0	1.20	1.20	1.20	1.20	1.20	1.20	1.20
1	0.70	0.70	0.70	0.70	0.70	0.70	0.70
2	0.60	0.60	0.60	0.60	0.60	0.60	0.60
3	0.52	0.52	0.52	0.52	0.52	0.52	0.52
4	0.50	0.50	0.50	0.50	0.50	0.50	0.50
5	0.48	0.48	0.48	0.48	0.48	0.48	0.48
6	0.48	0.48	0.48	0.48	0.48	0.48	0.48
7+	0.48	0.48	0.48	0.48	0.48	0.48	0.48
Maturity **Age**							
0	0.003	0.003	0.003	0.003	0.003	0.003	0.003
1	0.809	0.809	0.809	0.809	0.809	0.809	0.809
2	1.000	1.000	1.000	1.000	1.000	1.000	1.000
3	1.000	1.000	1.000	1.000	1.000	1.000	1.000

4	1.000	1.000	1.000	1.000	1.000	1.000	1.000
5	1.000	1.000	1.000	1.000	1.000	1.000	1.000
6	1.000	1.000	1.000	1.000	1.000	1.000	1.000
7+	1.000	1.000	1.000	1.000	1.000	1.000	1.000
SoleMon number (n/km^2) for GSA 17 **Age**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
0		17.117	16.556	10.538	3.909	12.765	11.505
1		244.699	292.582	148.246	161.797	224.766	202.589
2		276.455	236.81	190.212	283.334	261.767	235.939
3		47.558	51.134	57.706	70.386	60.158	54.222
4		3.14	5.725	9.227	4.252	5.927	5.342

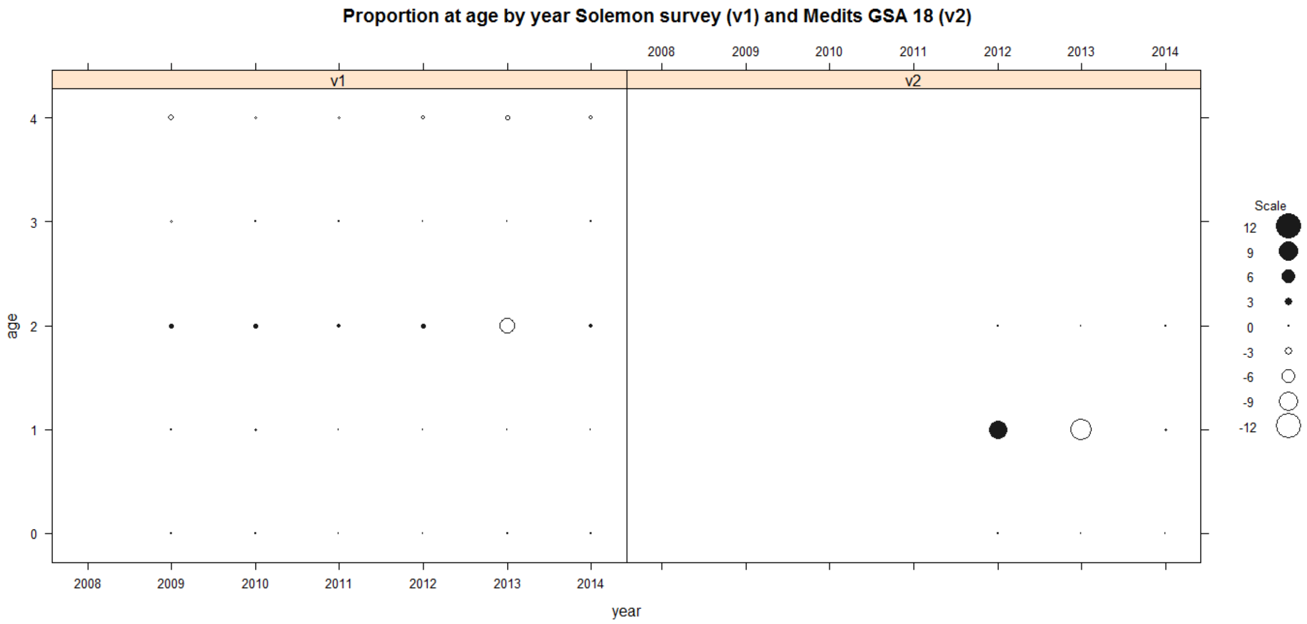


Figure 5.2.9.7.2.1. Spot-tail mantis shrimp in GSA 17-18. Bubble plot of residuals for an exploratory model carried out using SOLEMON in GSA 17 and MEDITS in GSA 18 as tuning index.

5.2.9.1.11 Results

A sensitivity analysis testing different shrinkage weights was performed before running the final XSA (Sh 0.5, 1.0, 1.5, 2.0, 2.5 and 3.0). Also, a sensitivity analysis of the *rage* parameter between 1 and 2 and *qage* parameter between 2 and 3 was carried out (Figures 5.2.9.7.3.1). The option with *rage* = 1, *qage* = 2 and *fse*=2 was selected as the best run (also checking the retrospective pattern, that in this run was slightly better compared to the others). The 5 best runs are ranked and summarized in table 5.2.9.7.3.1. Residuals from tuning fleets (SoleMon) per age and year were lower than 0.5 (absolute value) for all the year-age combinations, with the exception of age 4, constantly overestimated from the model (higher value = -2.48) probably due to the lower efficency of SOLEMON survey to catch big animals.

Table 5.2.9.7.3.1. Spot-tail mantis shrimp in GSA17-18. XSA run comparison: minimum, maximum and average residuals absolute value are ahown as well.

	fse	rage	qage	Min Residual	Max Residual	Average (abs value)
Run13	**2**	**1**	**2**	**-2.048**	**0.226**	**0.272**
Run12	1.5	1	2	-2.046	0.285	0.274
Run11	1	1	2	-2.038	0.332	0.282
Run9	2.5	2	3	-2.074	0.241	0.285
Run10	0.5	1	2	-2.015	0.364	0.295

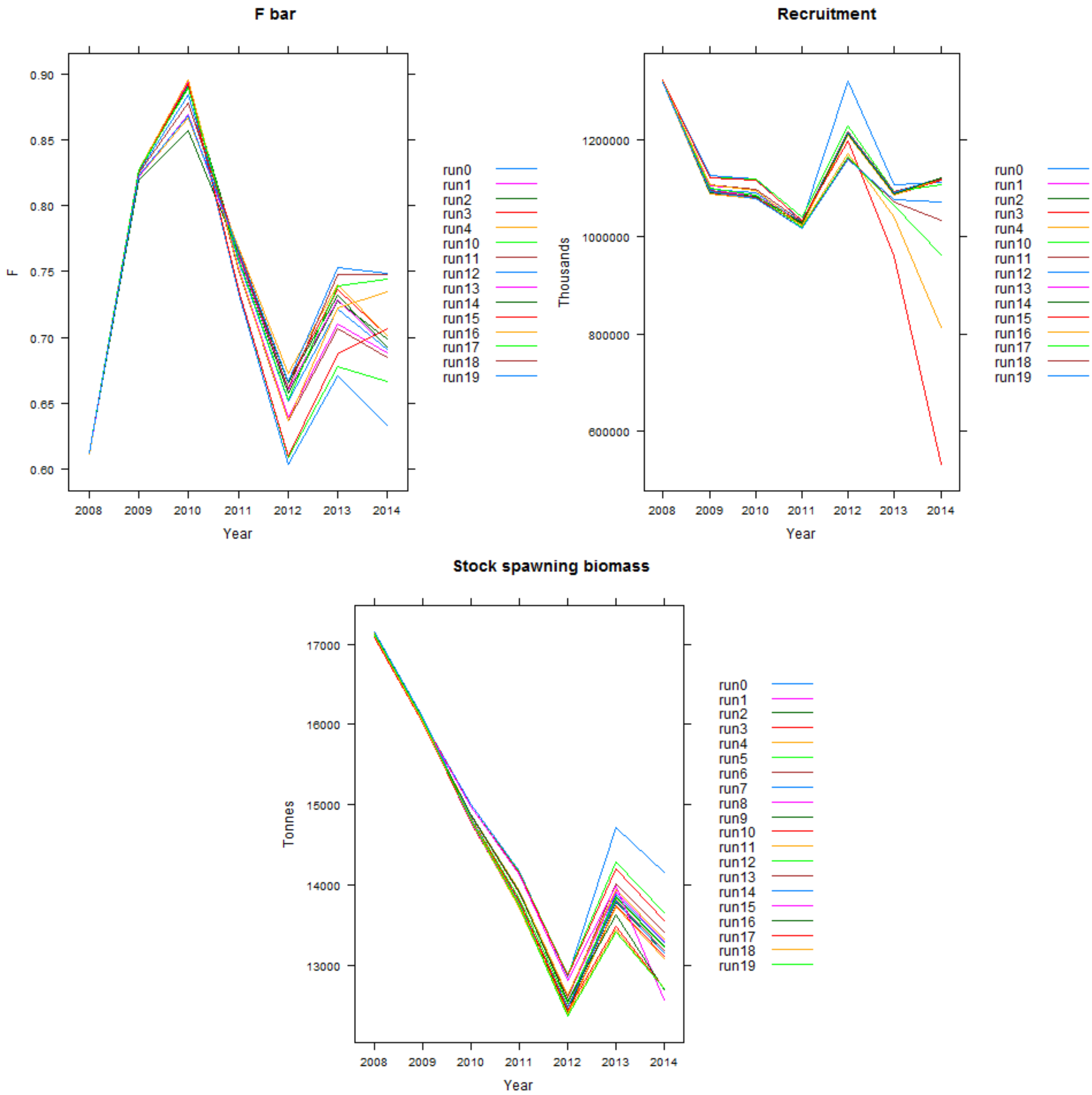


Figure 5.2.9.7.3.1. Spot-tail mantis shrimp in GSA17-18. XSA run comparison for F, Recruitment and SSB values.

XSA main outputs (Figure 5.2.9.7.3.2-3 and tables 5.2.9.7.3.2-4) show a decrease in fishing mortality from 2010 till 2014, which is equal to 0.69. Recruitment, after a decrease from 2008 to 2009, is quite stable in the last years. SSB decreases from a value of 17,127 to a value of 13,176 tonnes in 2014.

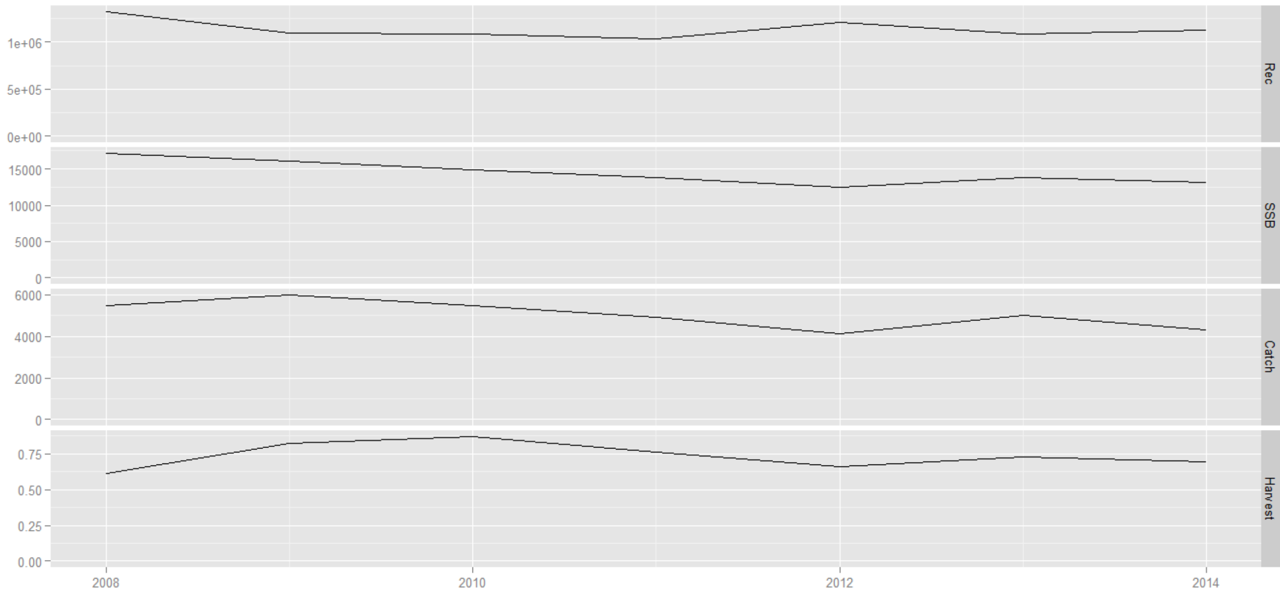


Figure 5.2.7.7.3.2. Spot-tail mantis shrimp in GSA 17-18. XSA summary results. SSB and catch are in tonnes, recruitment in 1000s individuals.

Table 5.2.9.7.3.2. Spot-tail mantis shrimp in GSA 17. F, Recruitment and SSB estimates by XSA 2008-2014.

Year	SSB	Recruitment	Fbar (1-3)
2008	17127	1320354	0.61
2009	16064	1094724	0.82
2010	14821	1085877	0.87
2011	13787	1029812	0.76
2012	12478	1212656	0.66
2013	13813	1089775	0.73
2014	13176	1121336	0.69

Table 5.2.9.7.3.3. Spot-tail mantis shrimp in GSA 17-18. Harvest by age estimates by XSA from 2008 to 2014.

Age	2008	2009	2010	2011	2012	2013	2014
0	0.02	0.02	0.01	0.02	0.02	0.02	0.01
1	0.16	0.32	0.21	0.35	0.26	0.39	0.22
2	0.68	1.15	1.16	0.92	0.83	0.87	0.90
3	1.00	1.00	1.24	1.01	0.90	0.92	0.96
4	1.15	0.56	1.93	0.36	0.90	0.47	0.91
5	2.18	0.16	2.74	0.22	0.52	0.35	0.63
6	1.49	0.59	2.04	0.58	0.98	0.33	0.81
7+	1.49	0.59	2.04	0.58	0.98	0.33	0.81

Table 5.2.9.7.3.4. Spot-tail mantis shrimp in GSA 17-18. Stock numbers by age estimates by XSA from 2008 to 2014.

Age	2008	2009	2010	2011	2012	2013	2014
0	1320400	1094700	1085900	1029800	1212700	1089800	1121300
1	338370	391420	324650	324840	304480	358960	320600

2	128910	143160	141190	130710	113630	117120	120880
3	37469	35964	24894	24350	28501	27326	26812
4	15591	8202	7888	4280	5269	6889	6463
5	5772	2999	2838	697	1809	1296	2616
6	3915	403	1578	113	346	665	565
7+	3240	1	599	1	216	439	610

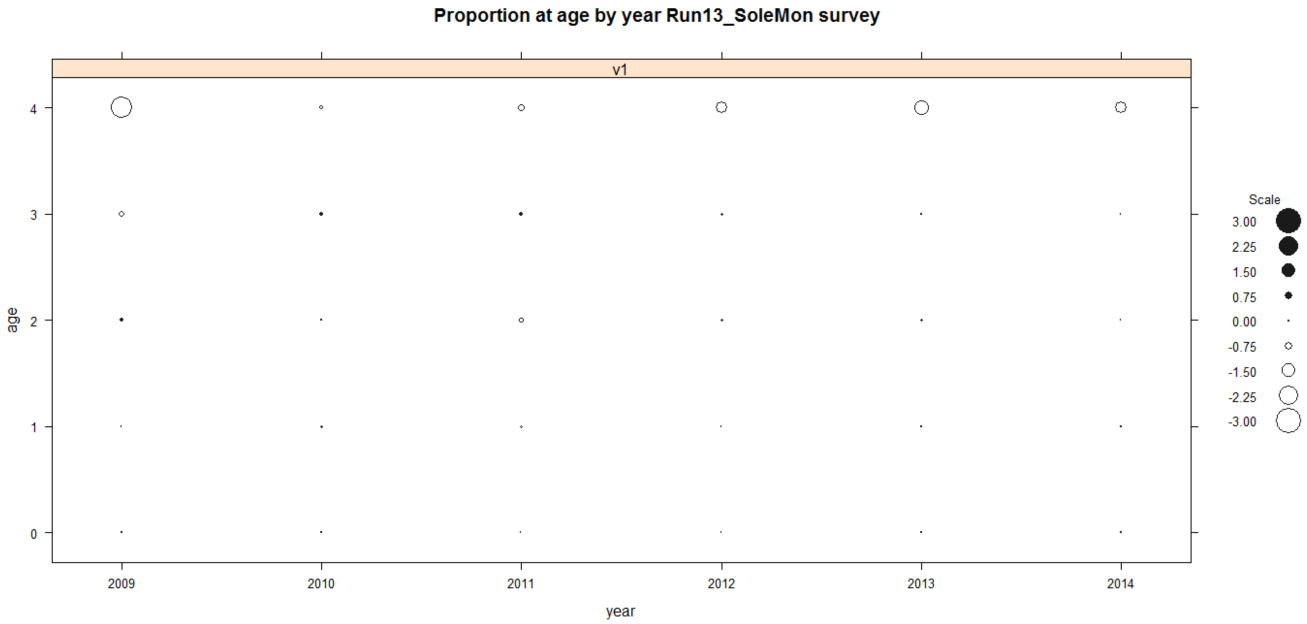


Figure 5.2.9.7.3.3. Spot-tail mantis shrimp in GSA 17-18. Bubble plot of residuals of for the final model.

Retrospective analysis was carried out and the time series of estimates for assessments terminating in 2014, 2013 and 2012 are plotted. The retrospective series indicate good agreement between years in the assessment results with no systematic bias. The estimates derived from retrospective assessments are plotted in figure Figure 5.2.9.7.3.4.

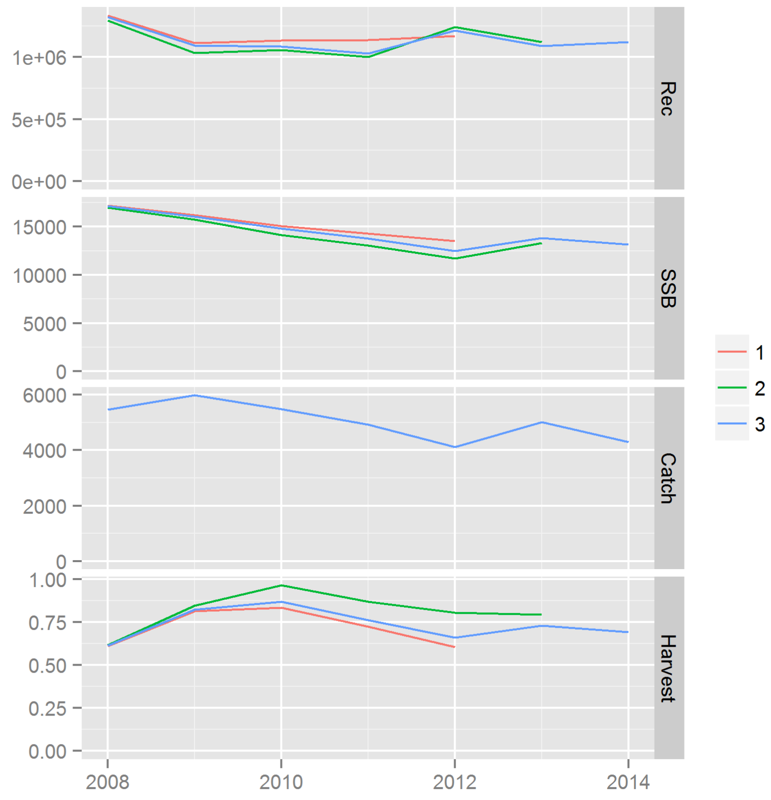


Figure 5.2.9.7.3.4. Spot-tail mantis shrimp in GSA 17-18. Retrospective pattern of the final XSA run for R, SSB and harvest.

Reference points

The yield per recruit (YpR) analysis was run using FLBRP routine and is reported in the figure 5.2.9.8.1. $F_{0.1}$ has been estimated equal to 0.56. $F_{current}$ (average of last three years) is equal to 0.69.

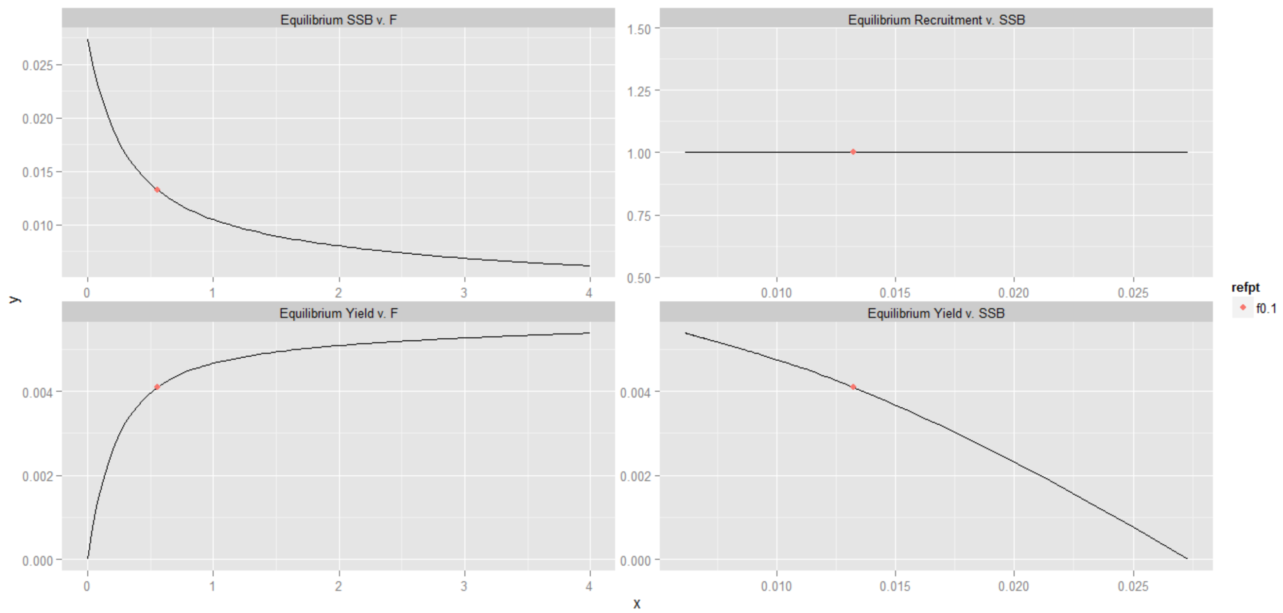


Figure 5.2.9.8.1. Spot-tail mantis shrimp in GSA 17-18. Yield per recruit outputs showing the position of the estimated $F_{0.1}$ =0.56.

Data quality

Spot-tail mantis shrimp data quality are described in sections 5.2.7.9 and 5.2.8.9 of this report.

Short term predictions 2016-2018

5.2.9.10.1 Method

A deterministic short term prediction for the period 2015 to 2017 was performed using the FLR routines provided by JRC, based on the results of the XSA stock assessments performed during EWG 15-16 for the years 2008–2014.

5.2.9.10.2 Input parameters

The same input parameters used in the XSA analysis showed above were used.

5.2.9.10.3 Results

Recruitment (class 0) has been estimated as the geometric mean of the last 3 years 2013-2014, taken from XSA results= 1,140,084 (thousands).
A short term projection table (Table 5.2.9.10.2.1) assuming a F status quo = 0.69 (average Fbar of last 3 years) in 2015 and a recruitment of 1,414,256 thousand individuals shows that:

- Fishing at F_{status_quo} from 2015 to 2017 would produce an increase in catches of about 14% and SSB would increase by 0.4% between 2016 and 2017.
- Fishing at F_{MSY} (0.56) from 2015 to 2016 would generate a decrease of 2.3% of the catches and an increase of 5.7% in SSB in 2017.
- Catches of Spot-tail mantis shrimp in 2016 consistent with FMSY would not exceed 4,189 tonnes.

Table 5.2.9.10.2.1. Spot-tail mantis shrimp in GSA17-18. Short term forecast in different F scenarios. Basis: F(2015) = mean(Fbar1-3 2012-2014)= 0.69; R(2015) = geometric mean of the recruitment of the last 3 years; R = 1140084 (thousands); SSB(2014) = 13176 t, Catch (2014)= 4288 t.

Rationale	Ffactor	Fbar	Catch 2014	Catch 2015	Catch 2016	Catch 2017	SSB 2016	SSB 2017	Change in SSB 2016-2017(%)	Change in Catch 2014-2016(%)
0 catch	0.00	0.00	4288	4863	0	0	13761	18958	37.8	-100.0
High long term yield ($F_{0.1}$)	0.81	0.56	4288	4863	4189	4496	13761	14549	5.7	-2.3
Status quo	1.00	0.69	4288	4863	4907	4929	13761	13817	0.4	14.4
Scenarios	0.10	0.07	4288	4863	636	920	13761	18277	32.8	-85.2
	0.20	0.14	4288	4863	1234	1702	13761	17640	28.2	-71.2
	0.30	0.21	4288	4863	1795	2367	13761	17046	23.9	-58.1
	0.40	0.28	4288	4863	2322	2932	13761	16490	19.8	-45.8
	0.50	0.35	4288	4863	2819	3413	13761	15970	16.1	-34.3
	0.60	0.41	4288	4863	3286	3821	13761	15482	12.5	-23.4
	0.70	0.48	4288	4863	3727	4169	13761	15026	9.2	-13.1

	0.80	0.55	4288	4863	4143	4464	13761	14597	6.1	-3.4
	0.90	0.62	4288	4863	4535	4715	13761	14195	3.2	5.8
	1.10	0.76	4288	4863	5258	5110	13761	13461	-2.2	22.6
	1.20	0.83	4288	4863	5590	5265	13761	13126	-4.6	30.4
	1.30	0.90	4288	4863	5906	5396	13761	12811	-6.9	37.7
	1.40	0.97	4288	4863	6205	5507	13761	12513	-9.1	44.7
	1.50	1.04	4288	4863	6489	5602	13761	12232	-11.1	51.3
	1.60	1.10	4288	4863	6759	5682	13761	11967	-13.0	57.6
	1.70	1.17	4288	4863	7016	5751	13761	11716	-14.9	63.6
	1.80	1.24	4288	4863	7260	5809	13761	11478	-16.6	69.3
	1.90	1.31	4288	4863	7493	5859	13761	11253	-18.2	74.8
	2.00	1.38	4288	4863	7716	5901	13761	11039	-19.8	79.9

Short term predictions 2015-2017 by fleet

5.2.9.1.12 Method

A deterministic short term prediction by fleet for the period 2015 to 2017 was performed using the FLR routines provided by JRC and based on the results of the XSA stock assessments performed during EWG 15-16. Four fleets were considered: trawlers in GSA 17 (OTB17), rapido trawlers and small-scale vessels using fixed nets (gillnets) in GSA 17 (OTHER17), trawlers in GSA 18 and small-scale vessels using fixed nets (gillnets and trammel-nets) in GSA 18 (OTHER18).

5.2.9.1.13 Input parameters

The same parameters used in the short term by single fleet were used.

5.2.9.1.14 Results

The main results of the short term predictions by fleet are shown in Table 5.2.9.11.3.1 and Figure 5.2.9.11.3.1.

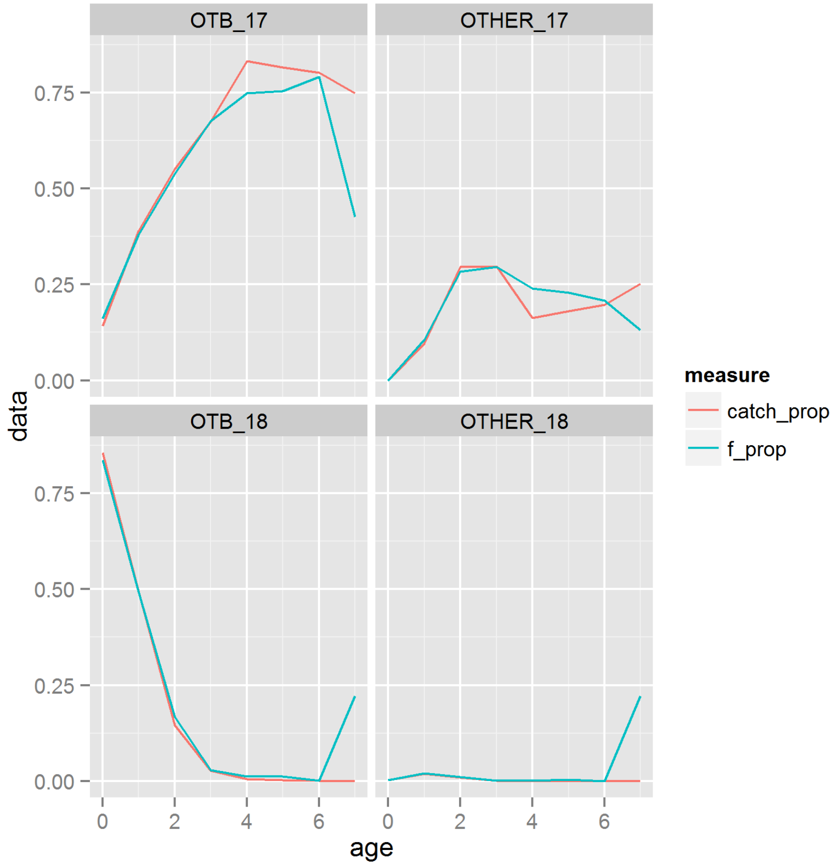


Figure 5.2.9.11.3.1. Spot-tail mantis shrimp in GSA17-18. Catch/fishing mortality proportion by fleet.

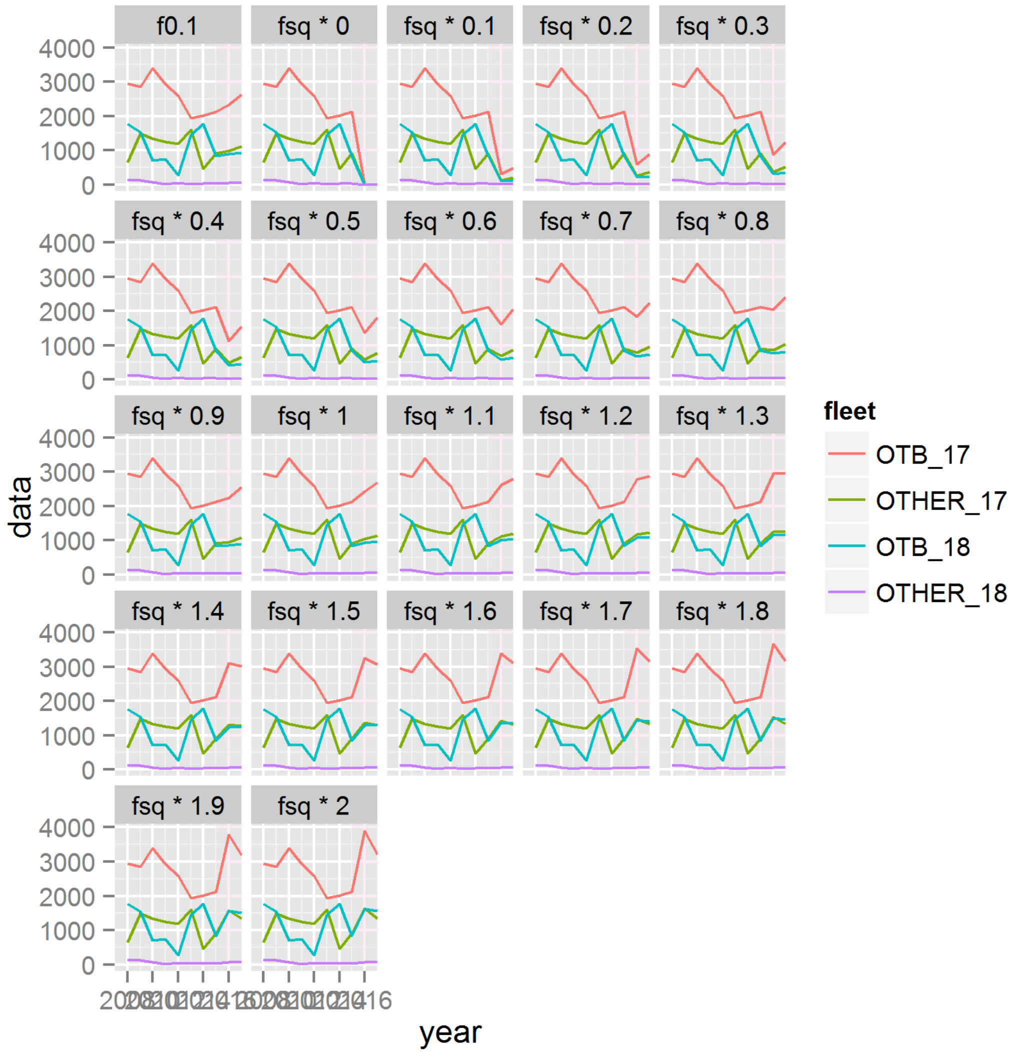


Figure 5.2.9.11.3.2. Spot-tail mantis shrimp in GSA 17-18. Selectivity by fleet, catch/fishing mortality proportion by fleet, catches by fleet for different fishing mortality scenarios.

Table 5.2.9.11.3.1. Spot-tail mantis shrimp in GSA 17-18. Short term forecast by fleet and GSA at current F (Fsq) and F_{MSY} ($F_{0.1}$).

Fleet	Year	Catches	F scenarios	Partial F
OTB_17	2015	2113.25	Fsq	0.304
OTB_17		2113.25	$F_{0.1}$	0.304
OTHER_17		903.80	Fsq	0.140
OTHER_17		903.80	$F_{0.1}$	0.140
OTB_18		841.34	Fsq	0.076
OTB_18		841.34	$F_{0.1}$	0.076
OTHER_18		37.70	Fsq	0.004
OTHER_18		37.70	$F_{0.1}$	0.004
OTB_17	2016	2427.48	Fsq	0.304
OTB_17		2326.58	$F_{0.1}$	0.288
OTHER_17		1031.20	Fsq	0.140

OTHER_17		989.09	$F_{0.1}$	0.132
OTB_18		925.99	Fsq	0.076
OTB_18		882.99	$F_{0.1}$	0.072
OTHER_18		41.49	Fsq	0.004
OTHER_18		39.62	$F_{0.1}$	0.004
OTB_17	2017	2681.93	Fsq	0.304
OTB_17		2618.49	$F_{0.1}$	0.288
OTHER_17		1137.24	Fsq	0.140
OTHER_17		1110.11	$F_{0.1}$	0.132
OTB_18		962.83	Fsq	0.076
OTB_18		922.96	$F_{0.1}$	0.072
OTHER_18		43.86	Fsq	0.004
OTHER_18		42.17	$F_{0.1}$	0.004

Following the agreement reached during the discussions of the EWG-12-19, medium term prediction would only be performed if there is a reliably fit of a stock-recruitment relationship. In the case of spot-tail mantis shrimp in GSA 17-18, the time-series available (2007-2014) is too short to derive any reliable relationships between recruits and SSB and therefore no medium term predictions were made.

Stock advice

The current $F_{1\text{-}3}$ (0.69) is larger than F_{MSY} (0.56), which indicates that spot-tail mantis shrimp is being fished above F_{MSY}. STECF EWG 15-16 recommends the relevant fleets' effort to be reduced until fishing mortality is below or at the proposed F_{MSY} level, in order to avoid future loss in stock productivity and landings. This should be achieved by means of a multi-annual management plan taking into account mixed-fisheries considerations. Catches of spot-tail mantis shrimp in GSA 17-18 in 2016 consistent with F_{MSY} should not exceed 4,189 t.

Management strategy evaluation

The Management Strategy Evaluation to evaluate if the F_{MSY} ranges are precautionary was run using R script provided during by STECF 15-16 and using as input data the output and parameters of the model presented in section 5.2.9.7 (Model 13). F ranges results were F_{upper}= 0.76 and F_{lower}= 0.37. B_{lim} was estimated in 12478 t (Figure 5.2.9.13.1).

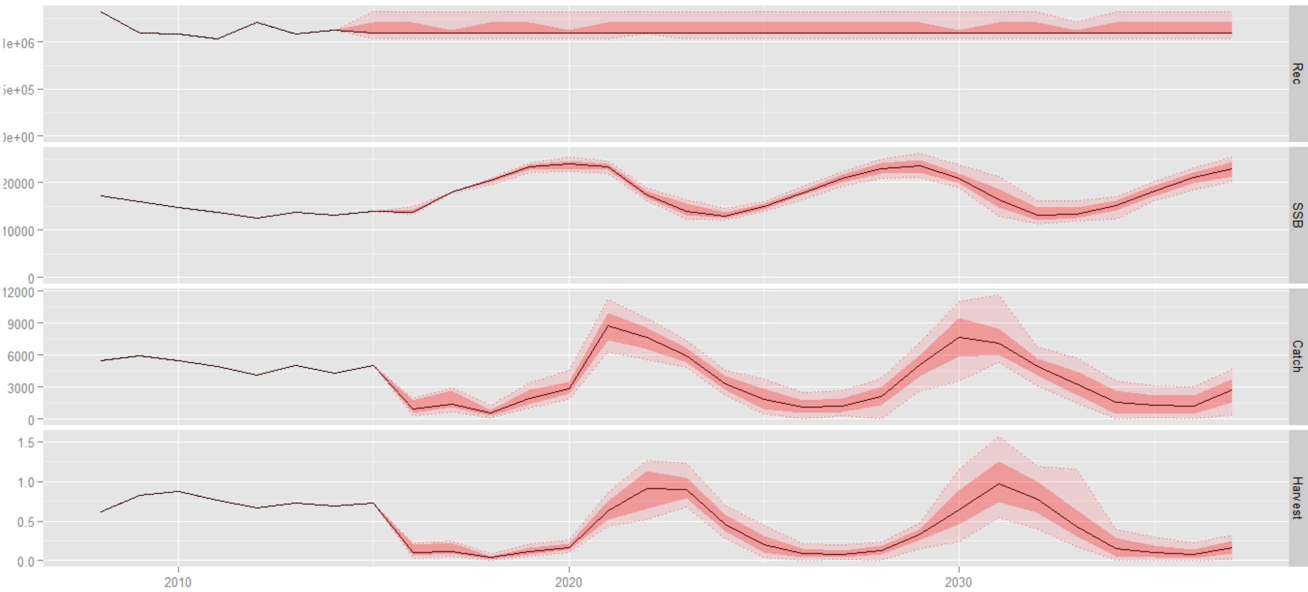


Figure 5.2.9.13.1. Spot-tail mantis shrimp in GSA 17-18. Marine Strategy Evaluation.

The results of the MSE simulations are not considered reliable and thus were not used to estimate the probability of SSB to fall below B_{lim} at F upper.

5.2.10 STOCK ASSESSMENT OF DEEP-WATER ROSE SHRIMP IN GSA 18

Stock Identification

The Southern Adriatic Sea extends from the line between Gargano and Lastovo to the boundary with the Ionian Sea at the latitude of Otranto (Artegiani et al., 1997). This southern section of the entire Adriatic Sea is characterised by the presence of a deep central depression known as the "South Adriatic Pit" (or Bari Pit). The seabed reaches a depth of 1,233 m in this area. The northern and southern portions of the Southern Adriatic Sea feature substantial differences; the first contains a wide continental shelf (the distance between the coastline and a depth of 200 m is around 45 nautical miles) and a very gradual slope; in the second, the isobathic contours are very close, with a depth of 200 m already found at around 8 miles from the Cape of Otranto. The continental shelf break is at a depth of around 160-200 m and is furrowed by the heads of canyons running perpendicular to the line of the shelf. The Adriatic Sea, together with the Levant basin, is one of three areas in the Mediterranean where down-welling processes produced by surface cooling lead to the formation of so-called "dense waters", rich in oxygen, which supply the lower levels (Cataudella and Spagnolo, 2011).

The stock of the deep-water rose shrimp was assumed in the boundaries of the whole GSA18, lacking specific information on stock identification.

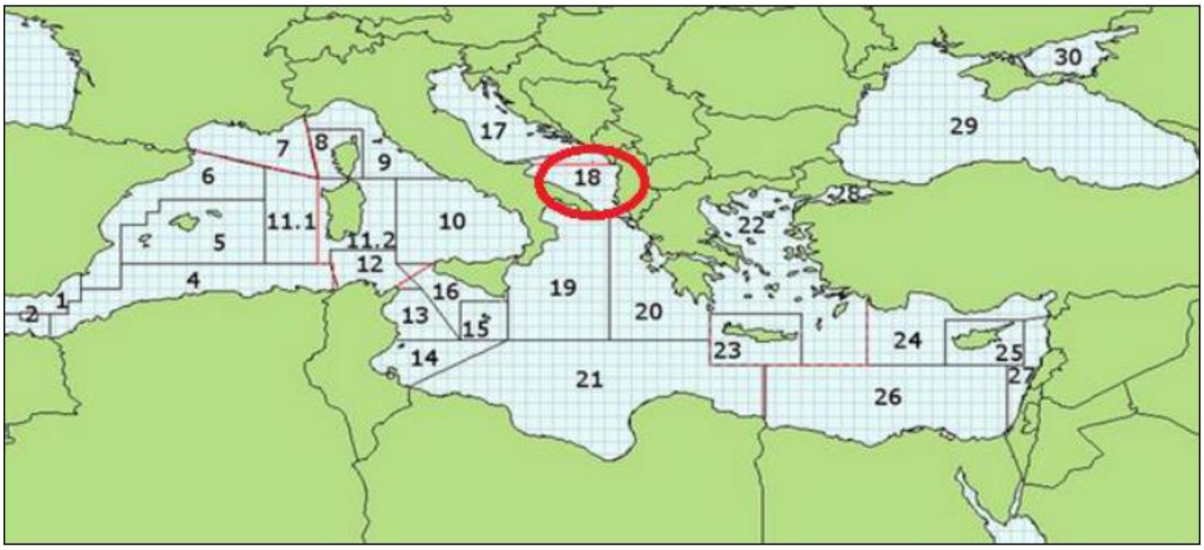


Figure 5.2.10.1.1. Geographical location of GSA 18.

Growth

According to historical information on growth in the Adriatic area, *P. longirostris* can grow up to 16 cm (males) and 19 cm (females) total length. However, males are usually 8 to 14 cm and females from 12 to 16 cm total length. During the expedition "Hvar", the largest specimen caught was a female 17 cm in length (Karlovac, 1949). The growth rate of *P. longirostris* is high, but differs between sexes. Size distribution and growth parameters indicate a life cycle of 3-4 years (Froglia, 1982). Historical parameters of the length-weight relationship reported in the literature for carapace length expressed in mm and both sexes combined (Marano *et al.*, 1998) are *a*=0.0034, *b*=2.4364.

Estimates of growth parameters estimated within the DCF framework using the length frequency distribution analysis and von Bertalanffy model gave the following parameters : CL_∞=45.0 mm; K=0.6; t_0= -0.20.

The parameters of the length-weight relationship estimated within the DCF for sexes combined and carapace length expressed in mm were: a=0.0043, b=2.376. These parameters were used in the assessment.

Maturity

In the Mediterranean Sea, both sexes of *P. longirostris* reaches maturity in the first year of life (Froglia, 1982). According to the data obtained in the Data Collection Framework (DCF), the maturity ogive (mature females were specimens belonging to the maturity stage 2 onwards) estimated by a maximum likelihood procedure indicates a $L_{m50\%}$ of about 18.5 mm (±0.026 mm) and a maturity range (MR; $L_{m75\%}$-$L_{m25\%}$) equal to 0.83 mm (±0.03 mm) of carapace length.

The sex ratio of commercial catches evidenced the prevalence of males in the size class from 16 to 18 mm and from 23 to 25 mm, while from 27 mm onwards the proportion of females was dominant.

The vector of proportion of mature individuals by age has been derived by slicing the maturity ogive by length with the von Bertalanffy coefficients for sex combined reported above.

Natural mortality

A vector of natural mortality was estimated by PRODBIOM method (Abella et al., 1997) for sex combined. See the assessment section below for more details.

Fisheries

The deep-water rose shrimp, is one of the target species of the central and southern Adriatic multispecies trawl catches.

5.2.10.1.1 General description of the fisheries

The Southern Adriatic sea makes a substantial contribution to national fishery production, with an input comparable to that of the Strait of Sicily, accounting for about 13% (Cataudella and Spagnolo, 2011). The exploitation of deep-water rose shrimp is mainly exerted by the bottom trawl fleets, both on the western and the eastern sides.

5.2.10.1.2 Management regulations applicable in 2015

In Italy management regulations are based on technical measures, closed number of fishing licenses for the fleet and area limitation (distance from the coast and depth). In order to limit the over-capacity of fishing fleet, the Italian fishing licenses have been fixed since the late eighties and the fishing capacity has been gradually reduced. Other measures on which the management regulations are based regards technical measures (mesh size), minimum landing sizes (EC 1967/06) and seasonal fishing ban, that in southern Adriatic has been mandatory since the late eighties.

In 2008 a management plan was adopted, that foresaw the reduction of fleet capacity associated with a reduction of the time at sea. Two biological conservation zone (ZTB) were permanently established in 2009 (Decree of Ministry of Agriculture, Food and Forestry Policy of 22.01.2009; GU n. 37 of 14.02.2009) along the mainland, offshore Bari (180 km2, between about 100 and 180 m depth), and in the vicinity of Tremiti Islands (115 km2 along the bathymetry of 100 m) on the northern border of the GSA where a marine protected area (MPA) had been established in 1989. In the former only the professional small scale fishery using fixed nets and long-lines is allowed, from January 1st to June 30th, while in the latter the trawling fishery is allowed from November 1st to March 31 and the small scale fishery all year round. Recreational fishery using no more than 5 hooks is allowed in both the areas. Since June 2010 the rules implemented in the EU regulation (EC 1967/06) regarding the cod-end mesh size and the operative distance of fishing from the coasts are enforced.

In Montenegro, management regulations are based on technical regulations, such as mesh size (Official Gazette of Montenegro, 8/2011), including the minimum landing sizes (Official Gazette of Montenegro, 8/2011), and a regulated number of fishing licenses and area limitation (no–fishing zone up to 3 NM from the coastline or 8 NM for trawlers of >24 m LOA). Currently there are no MPAs or fishing bans in Montenegrin waters.
In Albania, a new law "On fishery" has now been approved, repealing the Law n. 7908. The new law is based on the main principles of the CFP, it reflects Reg. 1224/2009 CE ; Reg.1005/2008 CE; Reg. 2371/2002 CE; Reg. 1198/2006 CE; Reg. 1967/2006 CE; Reg. 104/2000; Reg. 1543/2000. Also concerning conservation and management measures, minimum legal sizes and minimum mesh sizes are those proposed by EU Regulations.

5.2.10.1.3 Catches
Catches of deep-water rose shrimp are mainly from the otter bottom trawl fisheries carried out on both sides of the area. Discards are reported to be low.

5.2.10.1.4 Landings
Landings data in the table below are referred to the year 2014 (DCF data for Italy), while Albania and Montenegro landings are shown as reported by FAO Official Statistics (FAO, 2014), national statistics and Adriamed pilot study. All the landings reported are from the otter bottom trawl fleets operating in GSA 18.

Table 5.2.10.5.4.1. Deep-water rose shrimp in GSA 18. Landings (tons).

	OTB_Italy	OTB_Albania	OTB_Montenegro
2007	863	309	39
2008	762	309	39
2009	939	275	36
2010	888	409	32
2011	869	328	27
2012	523	335	22
2013	734	335	31
2014	638	291	28

Table 5.2.10.5.4.2. Deep-water rose shrimp in GSA 18. Landings (tons) by year and age structure from the Italian OTB fleet.

Age	2007	2008	2009	2010	2011	2012	2013	2014
0	267.8	224.7	279.1	228.4	176.3	202.4	254.0	273.5
1	515.1	482.1	602.4	587.9	621.5	291.6	444.9	339.4
2	76.6	56.6	54.9	67.8	66.8	28.1	33.9	24.2
3+	3.5	2.8	3.1	4.0	5.1	0.7	0.9	0.6

Table 5.2.10.5.4.3. Deep-water rose shrimp in GSA 18. Landings (tons) by year and age structure from the Albanian OTB fleet.

Age	2007	2008	2009	2010	2011	2012	2013	2014
0	144.63	144.63	135.10	196.66	164.36	163.72	123.55	122.78
1	163.88	163.88	139.17	211.70	162.95	170.07	210.00	167.75
2	0.86	0.86	0.73	1.02	0.81	0.81	1.05	0.32
3+	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 5.2.10.5.4.4. Deep-water rose shrimp in GSA 18. Landings (tons) by year and age structure from the Montenegro OTB fleet.

Age	2007	2008	2009	2010	2011	2012	2013	2014
0	10.16	10.16	7.33	4.32	9.37	4.64	5.28	7.73
1	26.11	26.11	24.61	23.83	16.52	15.35	23.21	19.67
2	2.72	2.72	3.71	4.16	0.82	1.87	2.36	0.81
3+	0.00	0.00	0.00	0.00	0.00	0.05	0.16	0.00

5.2.10.1.5 Discards

Discards data are available for the west side of GSA 18 only (DCF data) for the period 2009-2014. Discarding of deep-water rose shrimp by the Italian trawl fleet operating in GSA 18 is generally low.

Table 5.2.10.5.5.1. Deep-water rose shrimp in GSA 18. Discards (tons).

	OTB_Discards (DCF data)
2009	30.8
2010	17.5
2011	5.3
2012	7.2
2013	12.3
2014	7.7

Table 5.2.10.5.5.1. Deep-water rose shrimp in GSA 18. Discards (tons) by year and age structure from the Italian OTB fleet.

Age	2009	2010	2011	2012	2013	2014
0	21.7	14.1	5.1	6.6	12.0	7.6
1	8.8	3.3	0.1	0.6	0.3	0.1
2	0.3	0.1	0.02	0.00	0.00	0.00

5.2.10.1.6 Fishing effort

The nominal effort deployed by the Italian bottom trawl fleet operating in GSA 18 according to the DCF data is summarized in Table 5.2.10.5.6.1. The effort deployed in GSA 18 by the Italian bottom trawl fleet shows a decreasing trend. No information is available for the Albania and Montenegro bottom trawl fleets.

Table 5.2.10.5.6.1. Deep-water rose shrimp in GSA 18. Nominal effort (kWxDays and GTxDays) by the Italian bottom trawl fleet by "métier" and year (DCF data).

	kWxDays (OTB fleet)				GTxDays (OTB fleet)			
Year	**DEMSP**	**DWSP**	**MDDWSP**	**Total**	**DEMSP**	**DWSP**	**MDDWSP**	**Total**
2007	2822672		10017537	12840209	521821		1772419	2294240
2008	10723146	130964	609325	11463435	1890398	29701	119323	2039422
2009	12291687	108546	1478134	13878367	2101567	18235	266753	2386555
2010	9386636	124777	2344855	11856268	1608697	21524	437823	2068044
2011	9883344	46554	1399545	11329443	1607442	10809	281989	1900240
2012	9225895		596064	9821959	1536372		132377	1668749
2013	10087518		424108	10511626	1900071		94784	1994855
2014	7286976		449344	7736320	1383293		80351	1463644

Scientific surveys

5.2.10.1.7 Survey #1 (MEDITS)

5.2.10.1.7.1 Methods

The sampling design is random stratified with number of haul by stratum proportional to stratum surface. Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Hauls noted as valid were used only, including stations with no catches (zero catches are included). The abundance and biomass indices by GSA were calculated through stratified means. The variation of the stratified mean is then expressed as coefficient of variation respect to the mean.

5.2.10.1.7.2 Geographical distribution

The geographical distribution pattern of deep-water rose shrimp in the GSA 18 has been studied using trawl-survey data and geostatistical methods. In these studies the abundance indices of recruits were analysed. Results highlighted that areas located in the Gulf of Manfredonia and between Monopoli and Brindisi coasts within 200 m depth are characterised by high concentration of rose shrimp recruits reaching 2000 individuals/km2 in 2000-2001. A peak of 5000 individuals/km2 was observed in the southernmost location (border between GSA 18 and 19) off Capo S. Maria di Leuca (e.g. Carlucci et al., 2009). Rose shrimp nursery areas obtained applying the indicator kriging techniques are reported below (Fig. 5.2.10.1.7.2.1 and 2).

In the MEDISEH project (DG MARE Specific Contract SI2.600741, call for tenders MARE/2009/05), nursery areas and spawner aggregations have been detected, mainly in the eastern part of the GSA18, along the Albania coasts, where a persistent spawning ground is localized.

Warmer and saltier waters flowing in the eastern side are a favourable environmental condition for the preferential distribution of this species.

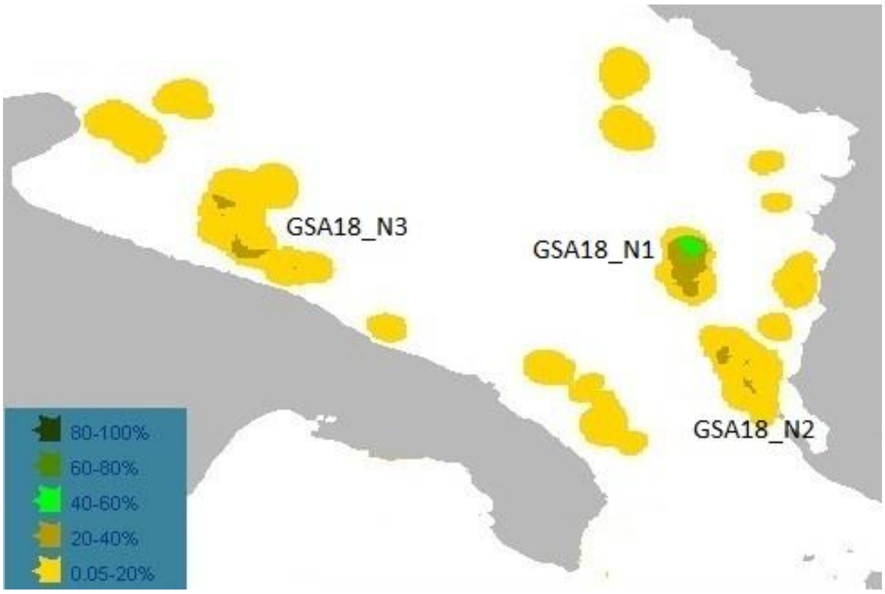


Figure 5.2.10.1.7.2.1. Deep-water rose shrimp in GSA 18. Locations of persistent nurseries.

Figure 5.2.10.1.7.2.2. Deep-water rose shrimp in GSA 18. Locations of persistent spawning areas.

5.2.10.1.7.3 Trends in abundance and biomass

Observed abundance and biomass indices of *P. longirostris* are given on the figures below (Figures 5.2.10.7.1.3.1-5.2.10.7.1.3.2). Both estimated abundance and biomass indices show similar trends, with a sharp drop in values in 2005-2007, a recovery until 2009 followed by a gradual drop until 2011 and a slight recovery in 2012. Table 5.2.10.7.1.3.1 is showing the same information.

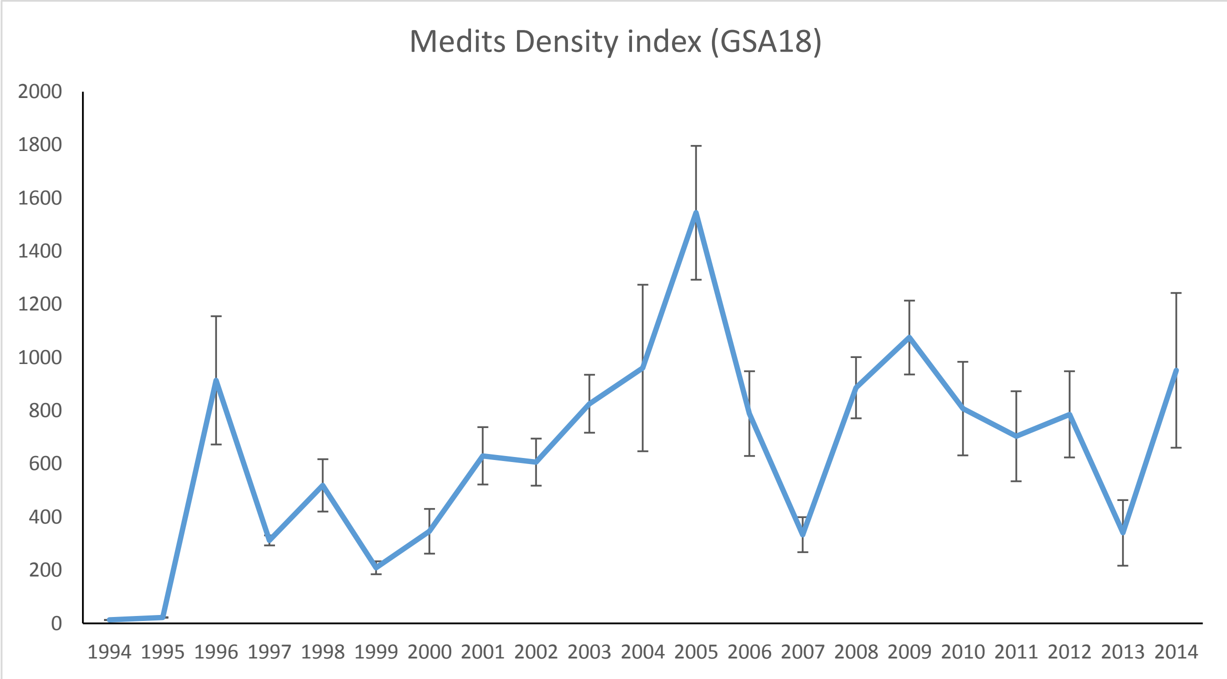


Figure 5.2.10.7.1.3.1. Deep-water rose shrimp in GSA 18. Estimated density indices (N/km^2), 1996–2014.

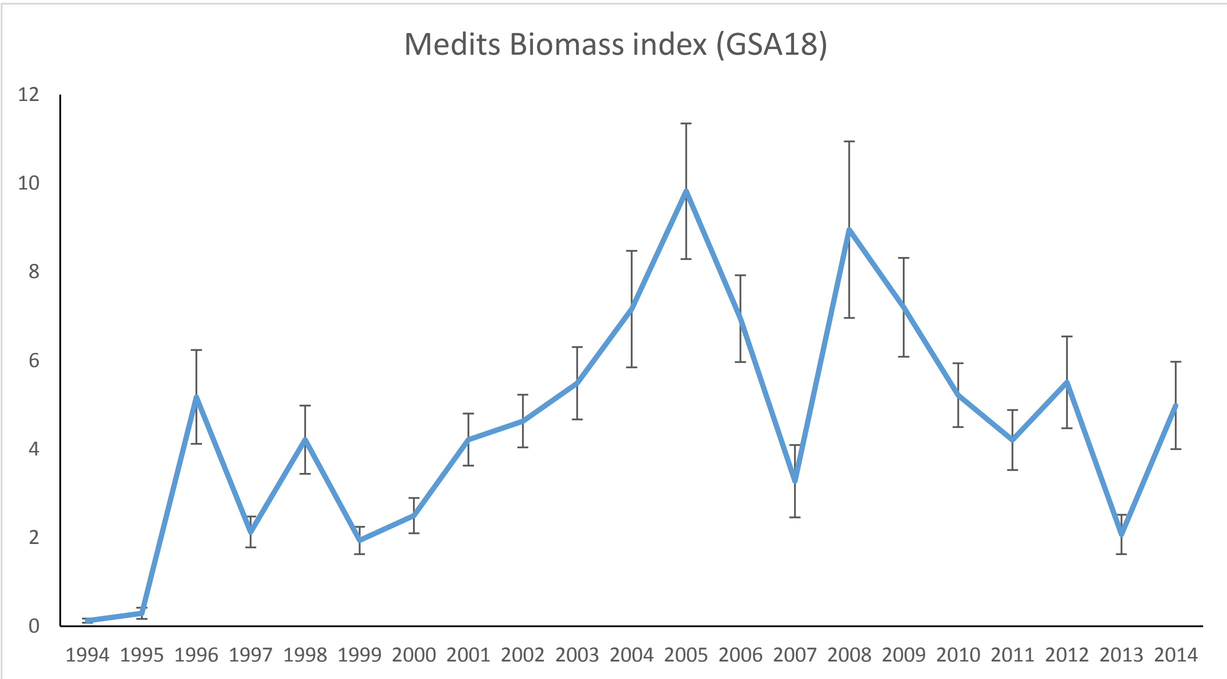


Figure 5.2.10.6.1.3.1. Deep-water rose shrimp in GSA 18. Estimated biomass indices (kg/km^2), 1996-2014.

Table 5.2.10.6.1.3.1. Deep-water rose shrimp in GSA 18. Trends in density (N/km^2) and biomass (kg/km^2) indices (and standard deviation, SD) from MEDITS survey in GSA 18, 1996-2014.

year	N/km^2	SD	kg/km^2	SD
1994	12.6	0.6	0.126	0.048
1995	22.3	1.1	0.295	0.126
1996	913.9	240.8	5.177	1.062
1997	311.8	18.5	2.128	0.350
1998	519.0	98.2	4.210	0.772
1999	208.9	24.4	1.937	0.311
2000	346.4	84.1	2.499	0.399
2001	630.1	108.2	4.213	0.588
2002	606.8	88.6	4.631	0.594
2003	826.0	108.8	5.484	0.817
2004	960.3	313.3	7.162	1.315
2005	1544.5	252.0	9.821	1.532
2006	789.2	159.6	6.944	0.978
2007	333.1	65.9	3.274	0.815
2008	886.3	115.4	8.951	1.991
2009	1075.3	139.1	7.199	1.117
2010	807.8	175.6	5.215	0.721
2011	703.7	169.4	4.204	0.679
2012	786.0	162.2	5.506	1.038
2013	340.4	123.2	2.072	0.446
2014	951.6	290.9	4.984	0.985

5.2.10.1.7.4 Trends in abundance by length or age

Trends in abundance by length and demographic structure obtained from MEDITS surveys are shown in Figures 5.2.10.6.1.4.1 and 5.2.10.6.1.4.2.

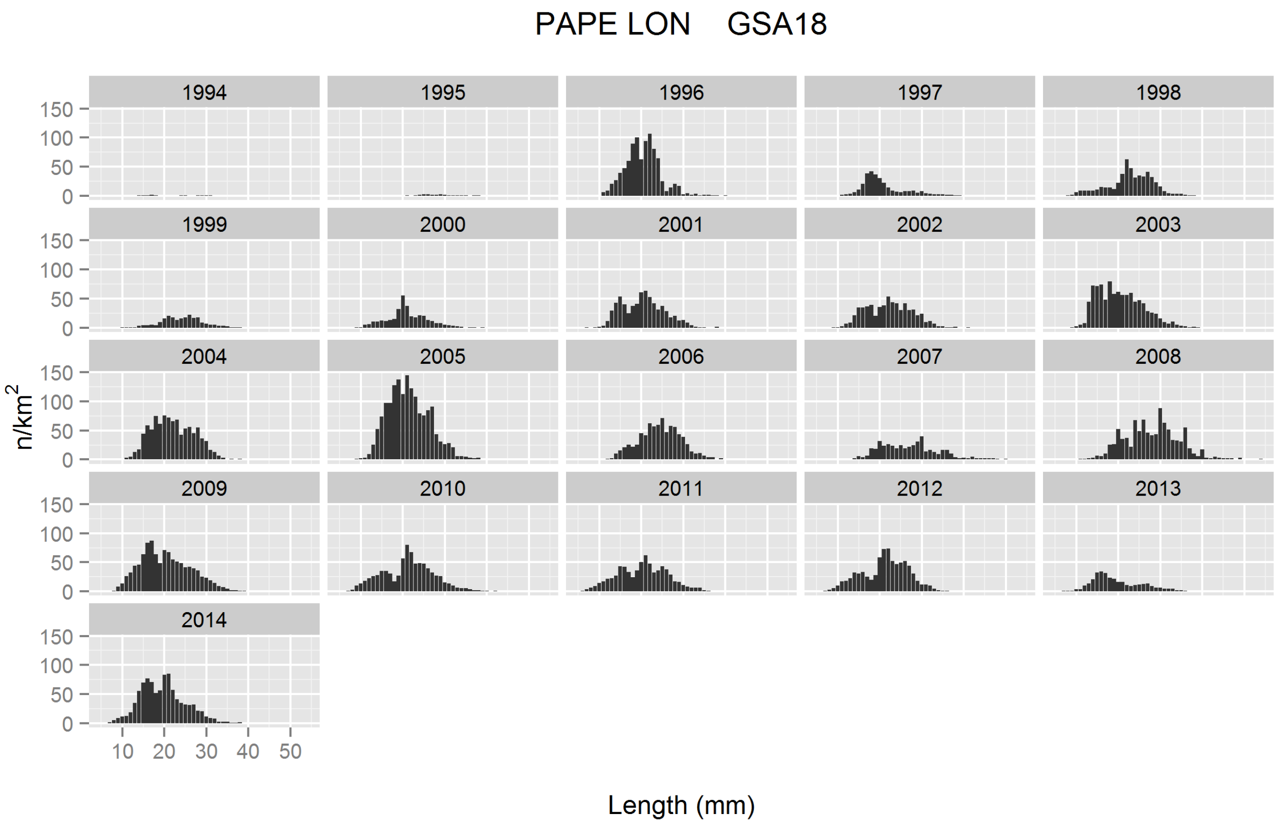


Figure 5.2.10.6.1.4.1. Deep-water rose shrimp in GSA 18. Density indices (N/km^2) by length class, 1994-2014. Sex combined.

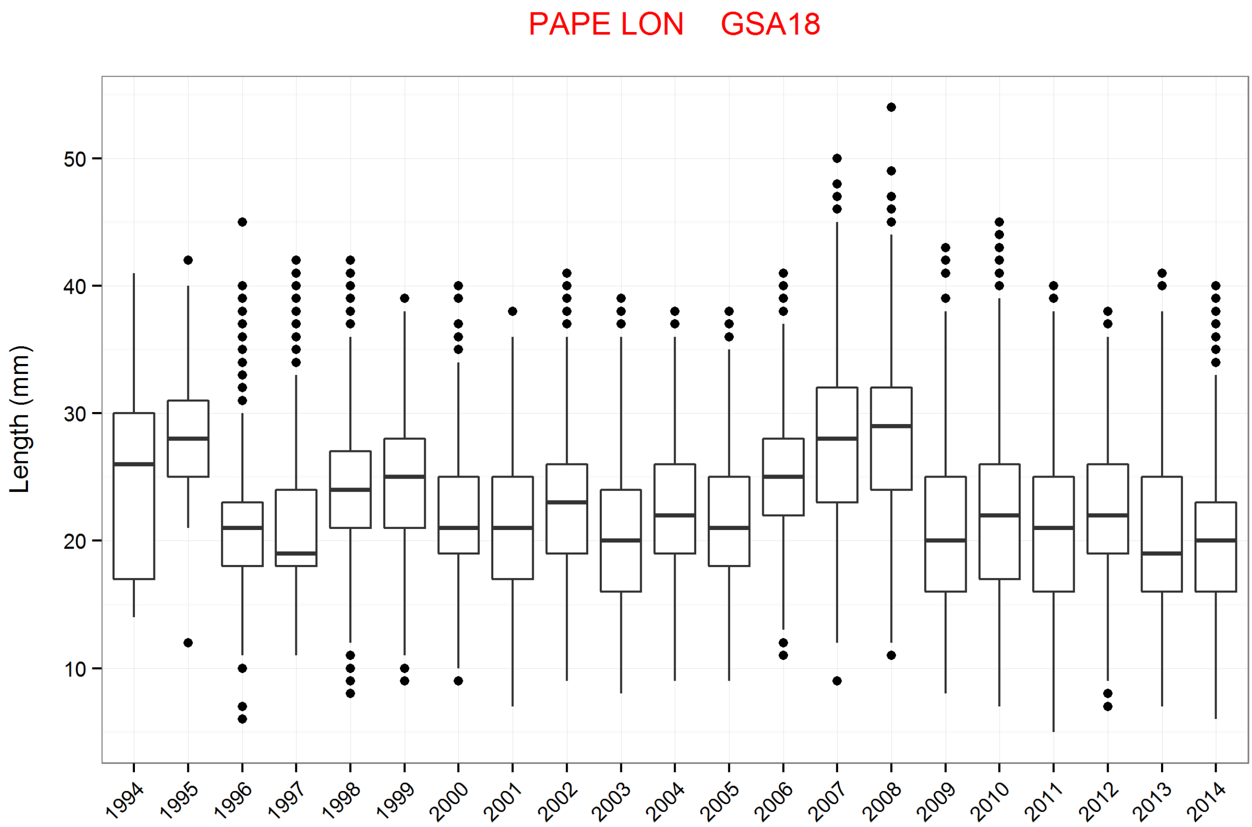


Figure 5.2.10.6.1.4.2. Deep-water rose shrimp in GSA 18. Box-plot summarizing the demographic structure by length, 1994-2014. Sex combined.

Stock Assessment

5.2.10.1.8 Method: XSA

FLR libraries were employed in order to carry out an Extended Survivor Analysis (XSA) assessment.

5.2.10.1.9 Input data

XSA uses catch numbers-at-age, mean weight-at-age, catches, proportion of mature individuals by age, and natural mortality by age to perform the analysis, which is tuned on survey data (MEDITS) by age. Standardized LFD abundance indices (N/km^2) for the whole GSA18 from MEDITS trawl survey data from 2007 to 2014 have been used as tuning data after having been transformed in age distributions by means of a knife-edge age slicing procedure (LFDA 5.0).

The length structure of landings from Italian fleet were collected under EU DCF, while those from Albania and Montenegro were obtained from national statistics and from the analysis and reconstruction carried out under the framework of the Adriamed pilot project.

Discards data were available for the western side only. The proportion of the discards of deep-water rose shrimp in the GSA 18 is generally lower than 10%. The collection of discards data was not carried out in DCF in 2007 and 2008. Therefore, the size distributions of discards in 2007 and 2008 were estimated by means of averaging discards data and size structures obtained in the period 2009-2014.

The catch numbers at length matrix was obtained summing distributions from Italian DCF data, those estimated on Albanian landings, and those from discards.
All the LFDs have been transformed in age distributions by means of a knife-edge age slicing procedure (LFDA 5.0) to be used as XSA input data.
Table 5.2.10.7.2.1 lists the input parameters to the XSA, namely catches, catch number at age, weight at age, maturity at age, natural mortality at age and the tuning series at age.

Table 5.2.10.7.2.1. Deep-water rose shrimp in GSA 18. Input data to the XSA model.

Catches (t) (Landings + Discards)

2007	2008	2009	2010	2011	2012	2013	2014
1229.2	1132.3	1280.9	1347.3	1229.7	886.5	1111.6	964.5

Catch numbers-at-age matrix (thousands)

Age	2007	2008	2009	2010	2011	2012	2013	2014
0	87513.3	78894.1	80589.1	88697.6	59198.7	62887.1	112808.4	82327.5
1	70781.0	67478.4	77499.6	87024.7	76288.2	43421.6	64608.3	47898.4
2	4015.0	3012.7	2981.6	4176.8	3422.9	1539.6	1866.4	1268.7
3+	129.8	103.9	111.5	169.5	182.7	29.5	38.7	22.9

Weights-at-age in the catch and in the stock (kg)

Age	2007	2008	2009	2010	2011	2012	2013	2014
0	0.005	0.005	0.006	0.005	0.006	0.006	0.004	0.005
1	0.010	0.010	0.010	0.010	0.011	0.011	0.011	0.011
2	0.020	0.020	0.020	0.018	0.020	0.020	0.020	0.020
3+	0.027	0.027	0.028	0.024	0.028	0.025	0.027	0.027

Maturity and natural mortality vectors.

Age	0	1	2	3+
Maturity	0.23	0.99	1.00	1.00
M	1.41	0.81	0.70	0.65

GSA 18, MEDITS number (n/km^2) at age.

Year/age	0	1	2	3+
2007	141.4	233.0	66.7	16.3
2008	209.1	538.2	177.2	38.9
2009	715.1	336.0	25.3	2.0
2010	476.5	303.5	24.8	4.3
2011	464.4	231.9	16.7	0.6
2012	456.2	322.5	9.0	0.1
2013	241.2	87.8	11.0	0.4
2014	702.8	237.7	10.1	1.1

5.2.10.1.10 Results

Sensitivity analyses were conducted to assess the effect of the main parameters. Values ranging from -1 to 1 for rage parameter and from 1 to 3 for qage parameter were tested. According to the residuals, the model with rage = -1 and qage = 1 provided the best fitting.

Then, values of shrinkage.age ranging from 1 to 3 were tested. The results showed that the best fitting was obtained using shk.age = 2.

Finally, values ranging from 0.5 to 3 (0.5 increasing) for the shrinkage have been tested. Comparison of trends between the settings has been done. Both the retrospective analysis and the residuals were used to choose the best model.

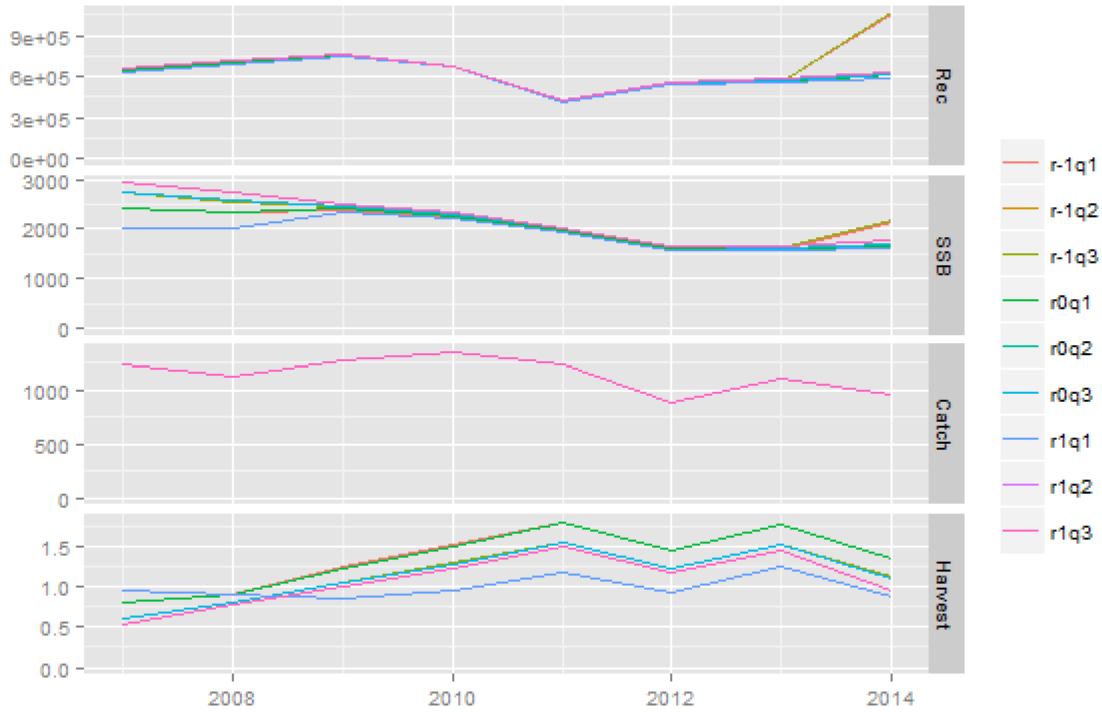


Figure 5.2.10.7.3.1. Deep-water rose shrimp in GSA 18. Sensitivity analysis on rage and qage parameters.

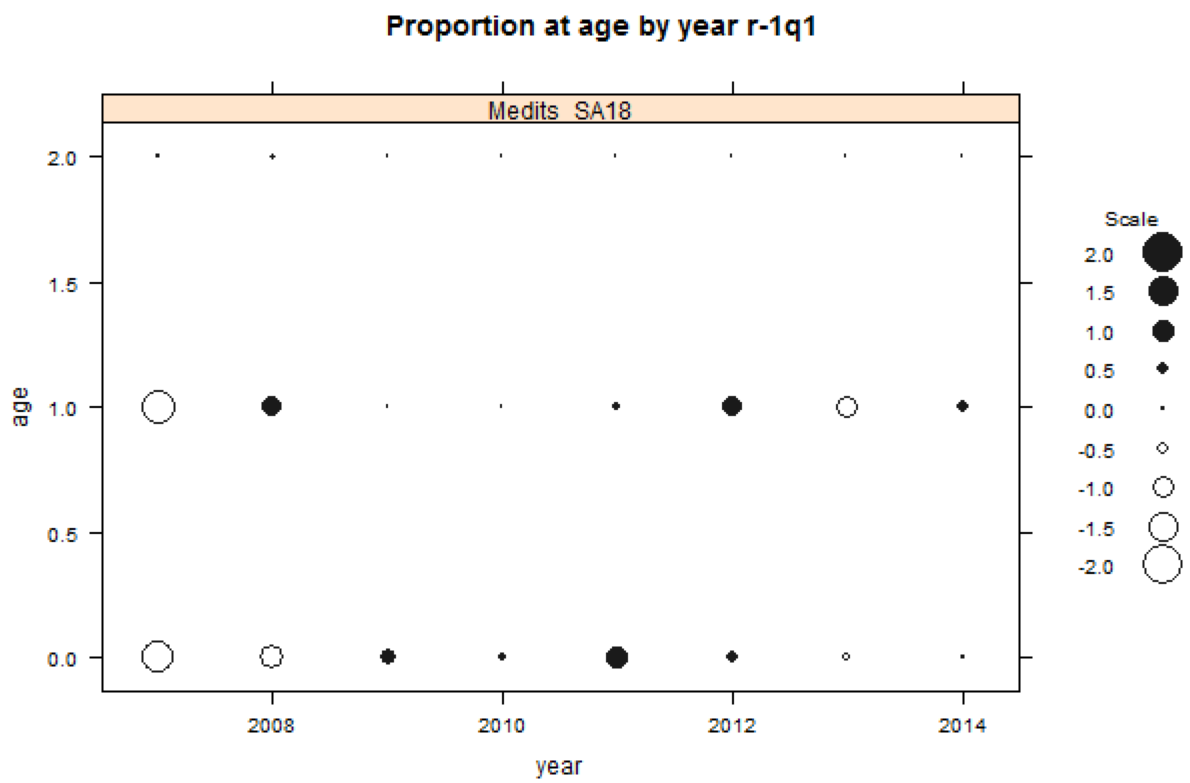


Figure 5.2.10.7.3.2. Deep-water rose shrimp in GSA 18. XSA model with rage = -1 and qage = 1: residuals for the MEDITS surveys from 2007 to 2014 in GSA 18.

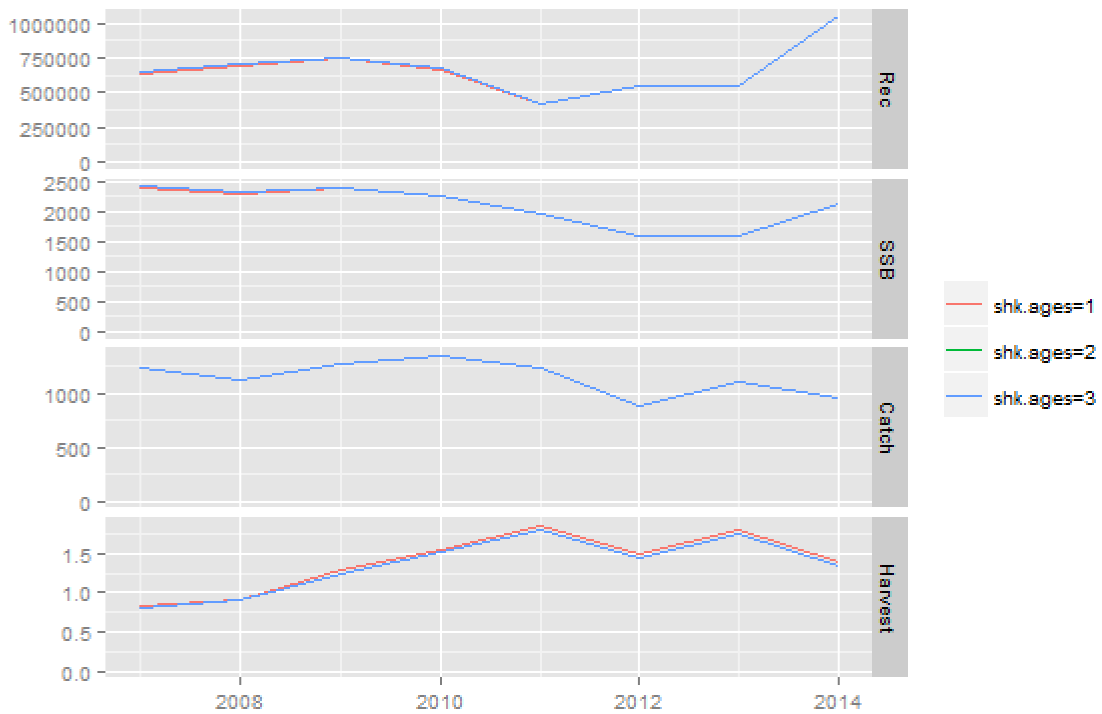


Figure 5.2.10.7.3.3. Deep-water rose shrimp in GSA 18. Sensitivity analysis on shk.age parameter.

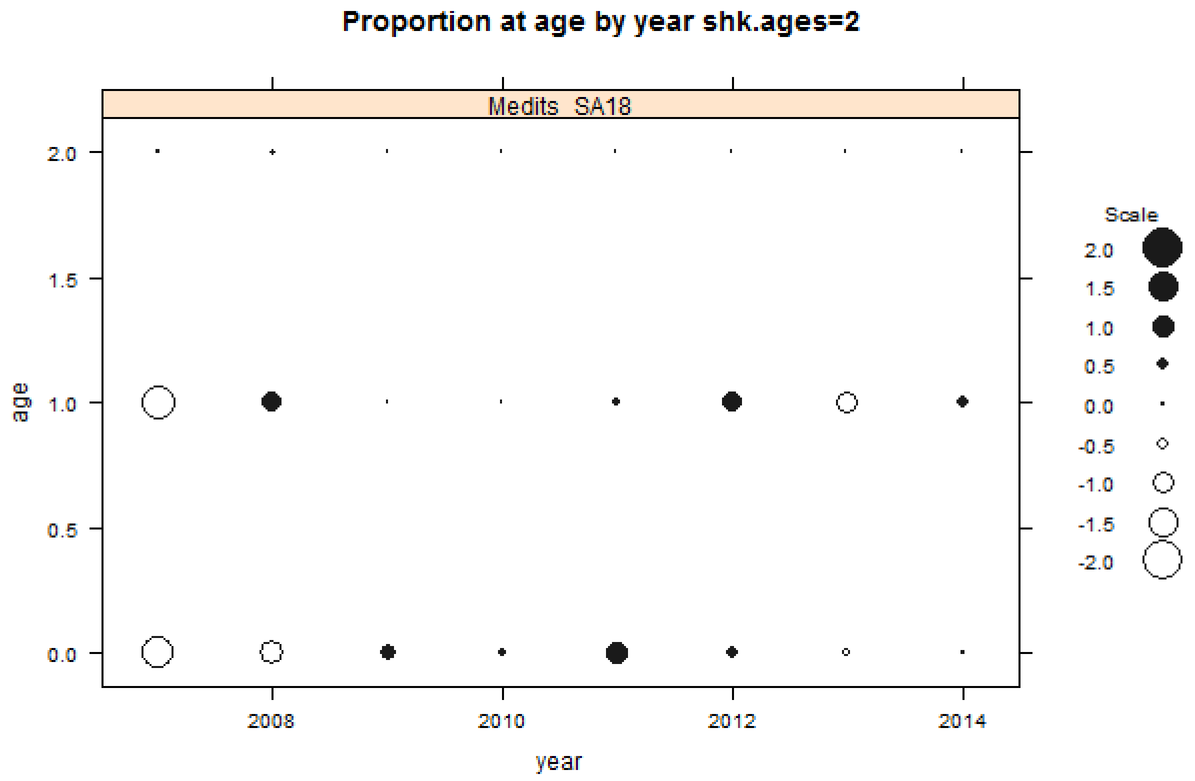


Figure 5.2.10.7.3.4. Deep-water rose shrimp in GSA 18. XSA model with rage = -1, qage = 1, and shk.age = 2: residuals for the MEDITS surveys from 2007 to 2014 in GSA 18.

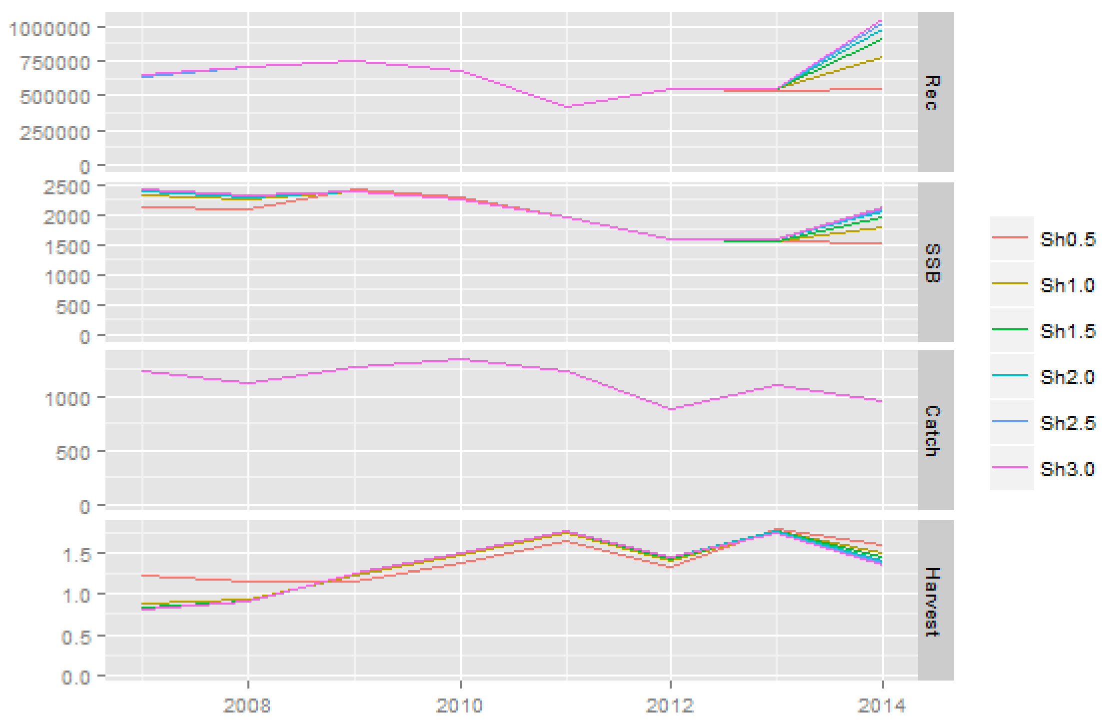


Figure 5.2.10.7.3.5. Deep-water rose shrimp in GSA 18. Sensitivity analysis on shrinkage weight.

The residuals patterns of the MEDITS trawl survey in GSA 18 are shown in Figure 5.2.10.7.3.2.

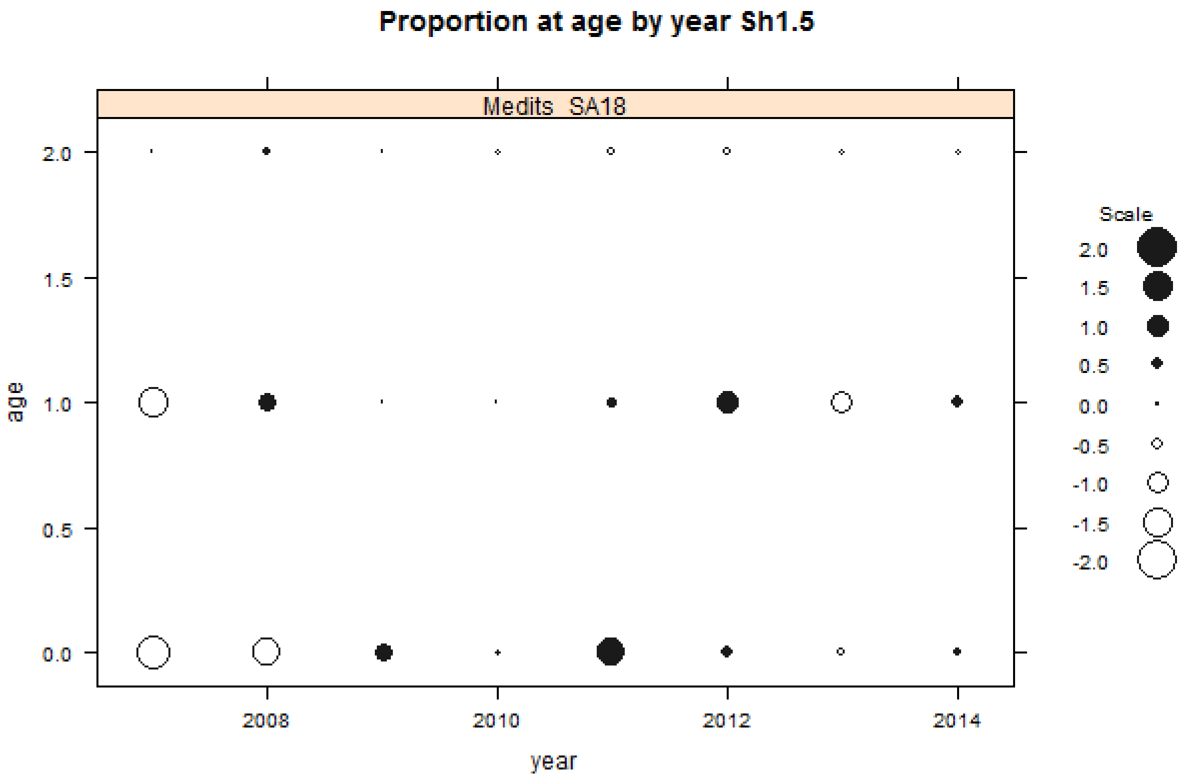


Figure 5.2.10.7.3.6. Deep-water rose shrimp in GSA 18. XSA residuals for the MEDITS surveys from 2007 to 2014 in GSA 18.

The results of the retrospective analysis on the XSA model with 1.5 shrinkage and rage = -1, qage = 1, and shk.age = 2 are shown in Figure 5.2.10.7.3.7

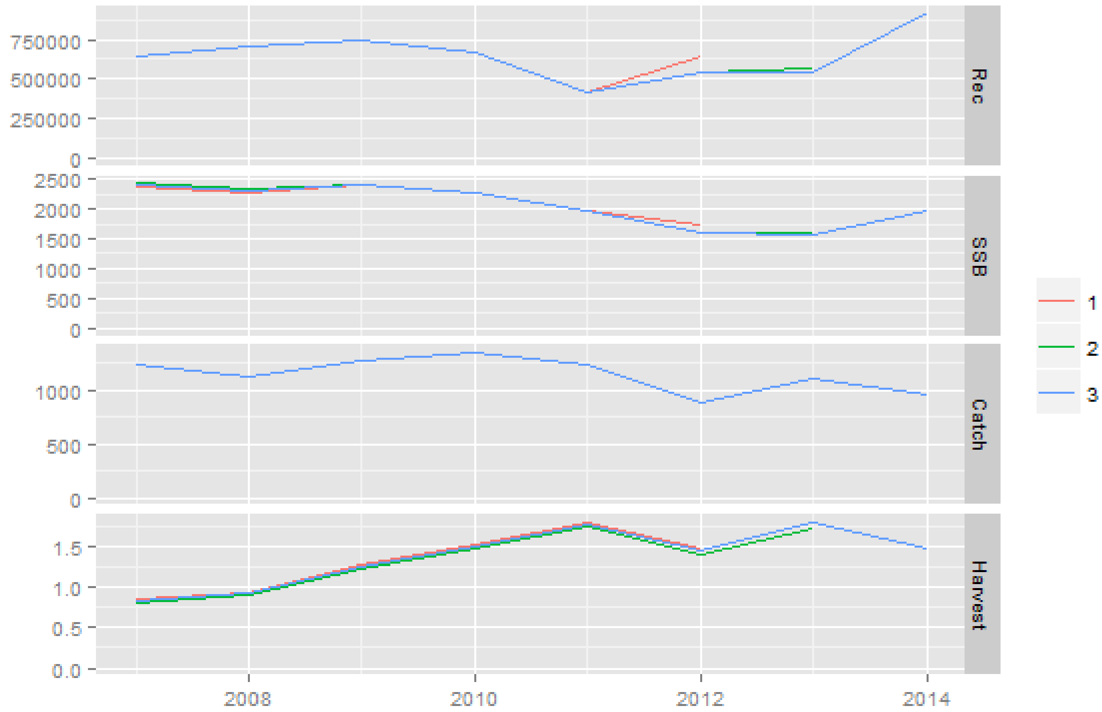


Figure 5.2.10.7.3.7. Deep-water rose shrimp in GSA 18. XSA retrospective analysis.

As a result, the settings that minimized the residuals and showed the best diagnostics output were used for the final assessment, and are the following:

Fbar	fse	rage	qage	shk.yrs	shk.age
0-2	1.5	-1	1	2	2

The results of the XSA are shown in Fig. 5.2.10.7.3.8. Recruitment, SSB, and catches are showing a slight decreasing trend, with a slight increasing pattern in the last few years. F remains at high levels.

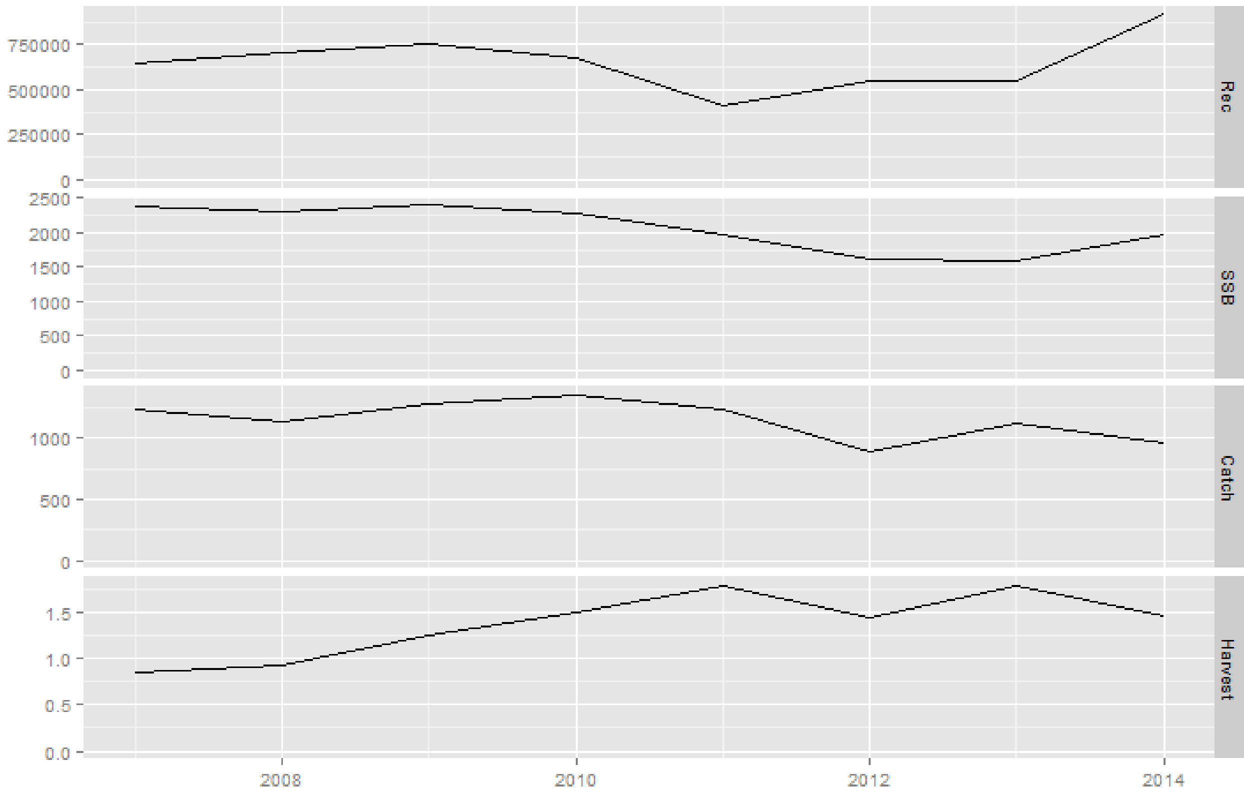


Figure 5.2.10.7.3.8. Deep-water rose shrimp in GSA 18. XSA results (fishing mortality, recruitment, SSB and yield).

The deep-water rose shrimp stock parameters obtained by means of XSA are provided in Tables 5.2.10.7.3.1-5.2.10.7.3.3.

Table 5.2.10.7.3.1. Deep-water rose shrimp in GSA 18. Stock numbers at age (thousands) as estimated by XSA.

Age	2007	2008	2009	2010	2011	2012	2013	2014
0	643293	701570	749318	672464	415487	545311	544045	916101
1	142677	113815	132301	143121	120351	72188	102061	77085
2	10062	16262	5625	7165	5625	2657	3152	2310
3+	304	540	191	259	265	45	58	38

Table 5.2.10.7.3.2. Deep-water rose shrimp in GSA 18. XSA summary results.

	Fbar0-2	Recruitment (thousands)	SSB (t)	TB (t)
2007	0.84	643293	2386	4853
2008	0.92	701570	2296	4986
2009	1.25	749318	2401	5937
2010	1.50	672464	2275	4929
2011	1.78	415487	1964	3937

2012	1.44	545311	1611	4120
2013	1.79	544045	1580	3363
2014	1.46	916101	1963	5476

Table 5.2.10.7.3.3. Deep-water rose shrimp in GSA 18. F-at-age matrix obtained from XSA.

	F at age			
	0	**1**	**2**	**3+**
2007	0.32	1.36	0.84	0.84
2008	0.26	2.20	0.31	0.31
2009	0.25	2.11	1.40	1.40
2010	0.31	2.43	1.76	1.76
2011	0.34	3.00	1.99	1.99
2012	0.27	2.32	1.73	1.73
2013	0.54	2.98	1.83	1.83
2014	0.20	2.68	1.51	1.51

Reference points

5.2.10.1.11 Methods

The FLBRP package allowed a Yield per recruit analysis and an estimate of some F-based Reference Points as F_{max} and $F_{0.1}$. Yield per Recruit computation was made using R project software and the FLR libraries. The fishing mortality rate corresponding to $F_{0.1}$ in the yield per recruit curve is considered here as a proxy of $F_{MSY.}$

5.2.10.1.12 Input data

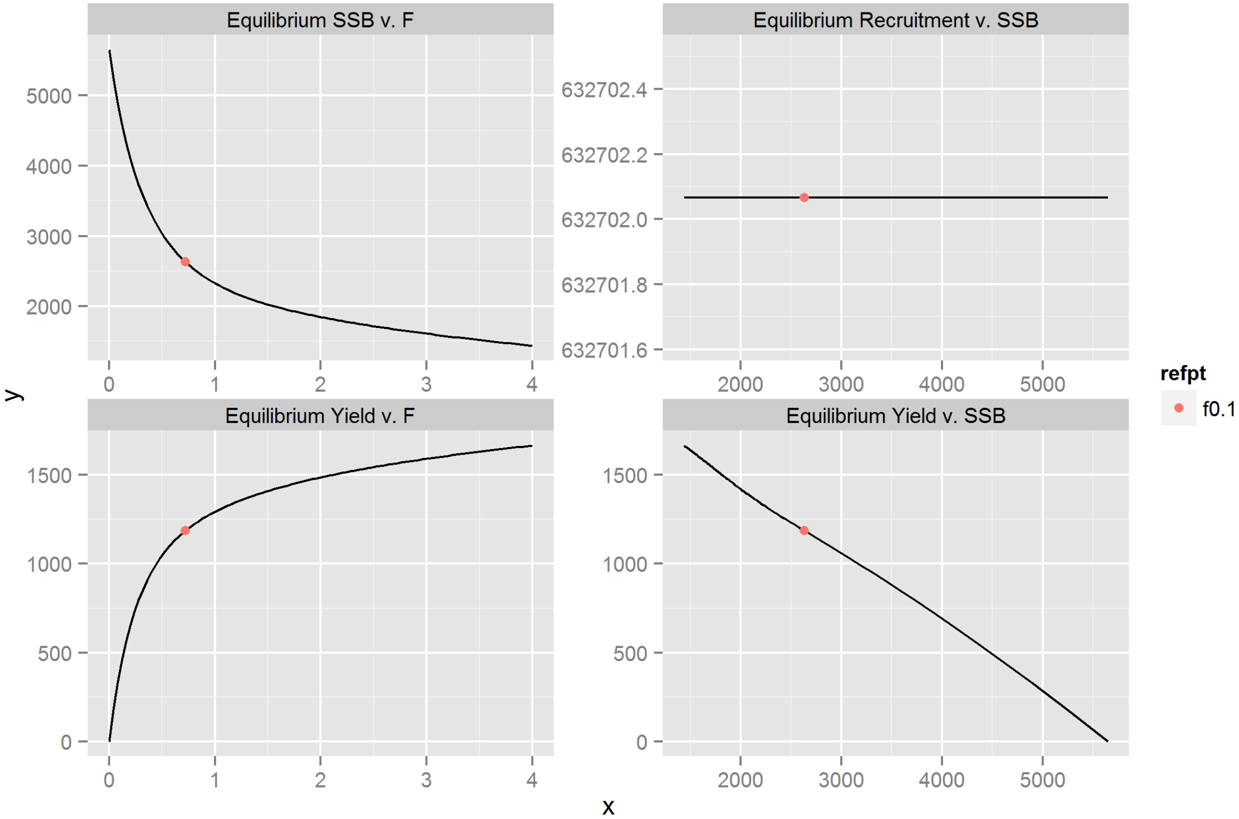
The input parameters were the same used for the XSA stock assessment and its results.

5.2.10.1.13 Results

Reference points were computed using FLBRP package. The estimated value for $F_{0.1}$ is 0.72 that is used as proxy for F_{MSY}.

Table 5.2.10.8.3.1. Deep-water rose shrimp in GSA 18. Reference points defined with the Yield per recruit analysis.

refpt	**harvest**	**Yield (t)**	**Recruitment (thousands)**	**SSB (t)**	**Biomass (t)**
f0.1	0.72	1186	632702	2634	4979



Figuree 5.2.10.8.3.1. Deep-water rose shrimp in GSA 18. Plots of the YPR analysis.

Data quality

The assessment was based on the EU DCF data (landings and discards) collected by Italy in the western part of GSA 18. Data from Albania and Montenegro were from FAO Official Statistics (FAO, 2014) and national statistics. Some of the landings data and size structure of the landings were collected and reconstructed under the framework of the Adriamed pilot project.

Short term predictions 2015-2017

5.2.10.1.14 Method

A deterministic short term prediction for the period 2015 to 2017 was performed using the FLR routines provided by JRC and based on the results of the XSA stock assessments performed during EWG 15-16.

5.2.10.1.15 Input parameters

The input parameters were the same used for the XSA stock assessment and its results. An average of the last three years has been used for weight at age, maturity at age and F at age.

Recruitment (age 0) has been estimated from the population results as the geometric mean of the last 3 years (647750 thousand individuals).

5.2.10.1.16 Results

Table 5.2.10.10.3.1. Deep-water rose shrimp in GSA 18. Short term forecast. Basis: F(2015) = mean(Fbar0-2 2012-2014) = 1.56; R(2015) = geometric mean of the recruitment of the last 3 years; R = 647,750 (thousands); SSB(2014) = 1963 t, Catch (2014) = 965 t.

Rationale	Ffactor	Fbar	Catch 2014	Catch 2015	Catch 2016	Catch 2017	SSB 2016	SSB 2017	Change SSB 2016-2017(%)	Change Catch 2014-2016(%)
Zero catch	0.00	0.00	965	2001	0	0	2077	3528	69.9	-100.0
High long term yield (F0.1)	0.46	0.72	965	2001	938	1150	2077	2527	21.7	-2.8
Status quo	1.00	1.56	965	2001	1483	1460	2077	2041	-1.7	53.8
Different Scenarios	0.10	0.16	965	2001	268	419	2077	3225	55.3	-72.2
	0.20	0.31	965	2001	493	713	2077	2981	43.5	-48.9
	0.30	0.47	965	2001	683	923	2077	2781	33.9	-29.2
	0.40	0.62	965	2001	846	1075	2077	2617	26.0	-12.3
	0.50	0.78	965	2001	986	1186	2077	2480	19.4	2.3
	0.60	0.93	965	2001	1110	1270	2077	2365	13.9	15.0
	0.70	1.09	965	2001	1218	1335	2077	2266	9.1	26.3
	0.80	1.24	965	2001	1316	1385	2077	2181	5.0	36.4
	0.90	1.40	965	2001	1403	1426	2077	2107	1.5	45.5
	1.10	1.71	965	2001	1556	1489	2077	1982	-4.6	61.4
	1.20	1.87	965	2001	1624	1514	2077	1928	-7.2	68.4
	1.30	2.02	965	2001	1687	1536	2077	1879	-9.5	74.9
	1.40	2.18	965	2001	1746	1556	2077	1833	-11.7	81.1
	1.50	2.33	965	2001	1802	1574	2077	1791	-13.7	86.8
	1.60	2.49	965	2001	1855	1591	2077	1752	-15.6	92.3
	1.70	2.64	965	2001	1905	1606	2077	1714	-17.4	97.5
	1.80	2.80	965	2001	1953	1621	2077	1679	-19.1	102.5
	1.90	2.95	965	2001	1999	1635	2077	1646	-20.8	107.2
	2.00	3.11	965	2001	2042	1648	2077	1614	-22.3	111.7

Short term predictions 2015-2017 by fleet

5.2.10.1.17 Method

A deterministic short term prediction by fleet for the period 2015 to 2017 was performed using the FLR routines provided by JRC and based on the results of the XSA stock assessments performed during EWG 15-16.

5.2.10.1.18 Input parameters

The same parameters used in the short term by single fleet were used.

5.2.10.1.19 Results

The main results of the short term predictions by fleet are shown in Table 5.2.10.11.3.1 and Figure 5.2.10.11.3.1.

Table 5.2.10.11.3.1. Deep-water rose shrimp in GSA 18. Short term forecast by fleet and GSA.

Fleet	year	Catches (tons)	F scenario
Italy_OTB	2015	1384.7	F_{sq}
Italy_OTB	2016	1024.6	F_{sq}
Italy_OTB	2017	1003.5	F_{sq}
Italy_OTB	2015	1384.7	$F_{0.1}$
Italy_OTB	2016	656.7	$F_{0.1}$
Italy_OTB	2017	827.5	$F_{0.1}$
Albania_OTB	2015	558.5	F_{sq}
Albania_OTB	2016	416.8	F_{sq}
Albania_OTB	2017	416.3	F_{sq}
Albania_OTB	2015	558.5	$F_{0.1}$
Albania_OTB	2016	256.0	$F_{0.1}$
Albania_OTB	2017	289.1	$F_{0.1}$
Montenegro_OTB	2015	57.8	F_{sq}
Montenegro_OTB	2016	41.7	F_{sq}
Montenegro_OTB	2017	40.5	F_{sq}
Montenegro_OTB	2015	57.8	$F_{0.1}$
Montenegro_OTB	2016	27.4	$F_{0.1}$
Montenegro_OTB	2017	34.8	$F_{0.1}$

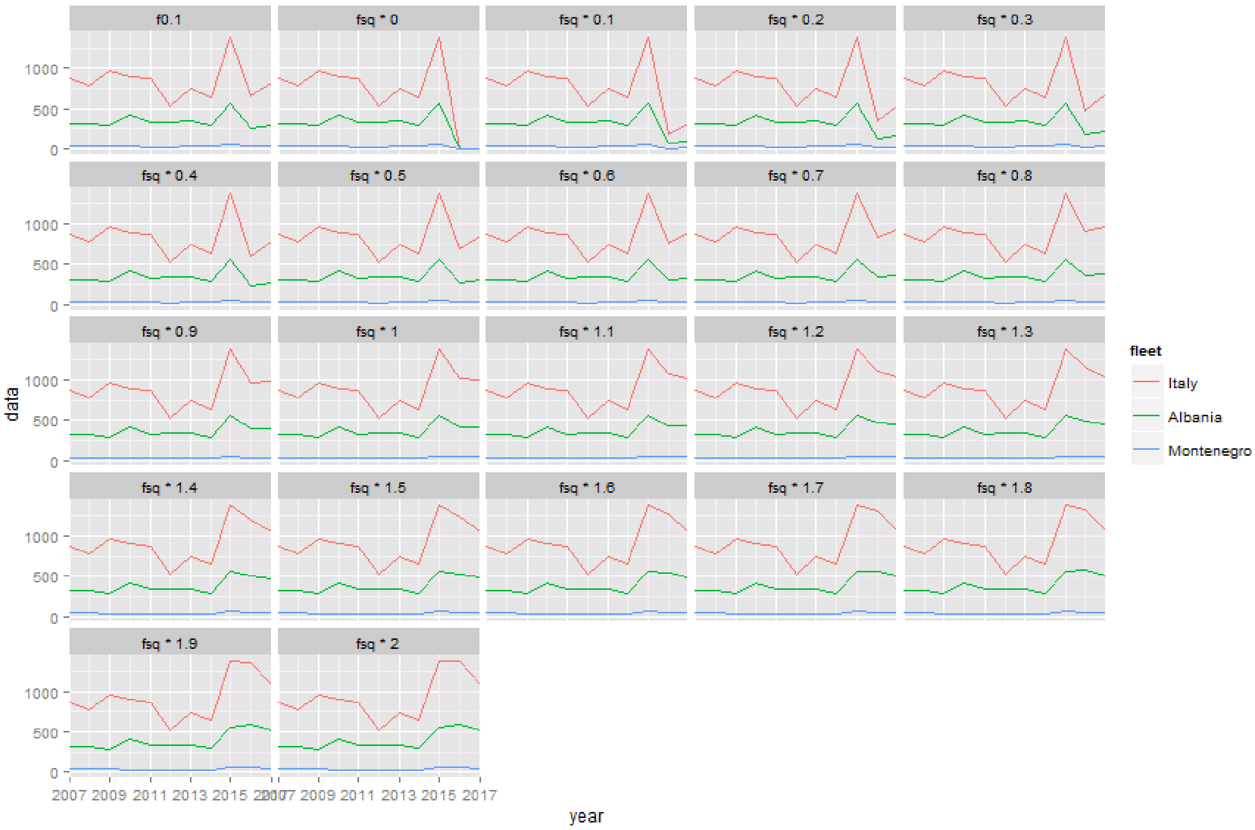


Figure 5.2.10.11.3.1. Deep-water rose shrimp in GSA 18. Catches by fleet at scenario from short term forecast by fleet.

Medium term predictions

Medium term forecasts were not conducted because no meaningful stock-recruitment relationship was estimated.

5.2.10.1.20 Method

Not applicable.

Stock advice

The current F (1.56, computed as the geometric mean of the last three years, 2012-2014) is larger than $F_{0.1}$ (0.72), chosen as proxy of F_{MSY} and as the exploitation reference point consistent with high long term yields, which indicates that deep-water rose shrimp in GSA 18 is exploited above F_{MSY}. Catches of deep-water rose shrimp in 2016 consistent with F_{MSY} (0.72) would not exceed 788 tonnes.

Management strategy evaluation

A Management Strategy Evaluation was run to evaluate if the MSY ranges were precautionary. The F_{MSY} ranges were derived using the formula provided by STECF EWG 15-09. F ranges results were F_{upper}=0.98 and F_{lower}=0.48. B_{lim} was estimated as B_{loss}=1580 (t). The following figure shows the results of the MSE. Probability to fall below B_{lim} at F = F_{upper} is equal to 0.

Table 5.2.10.14.1. Deep-water rose shrimp in GSA 18. Reference points used to run the MSE routine.

F_{MSY}	F_{upp}	F_{low}	B_{lim} (tons)	B_{pa} (tons)
0.72	0.98	0.48	1580	2212

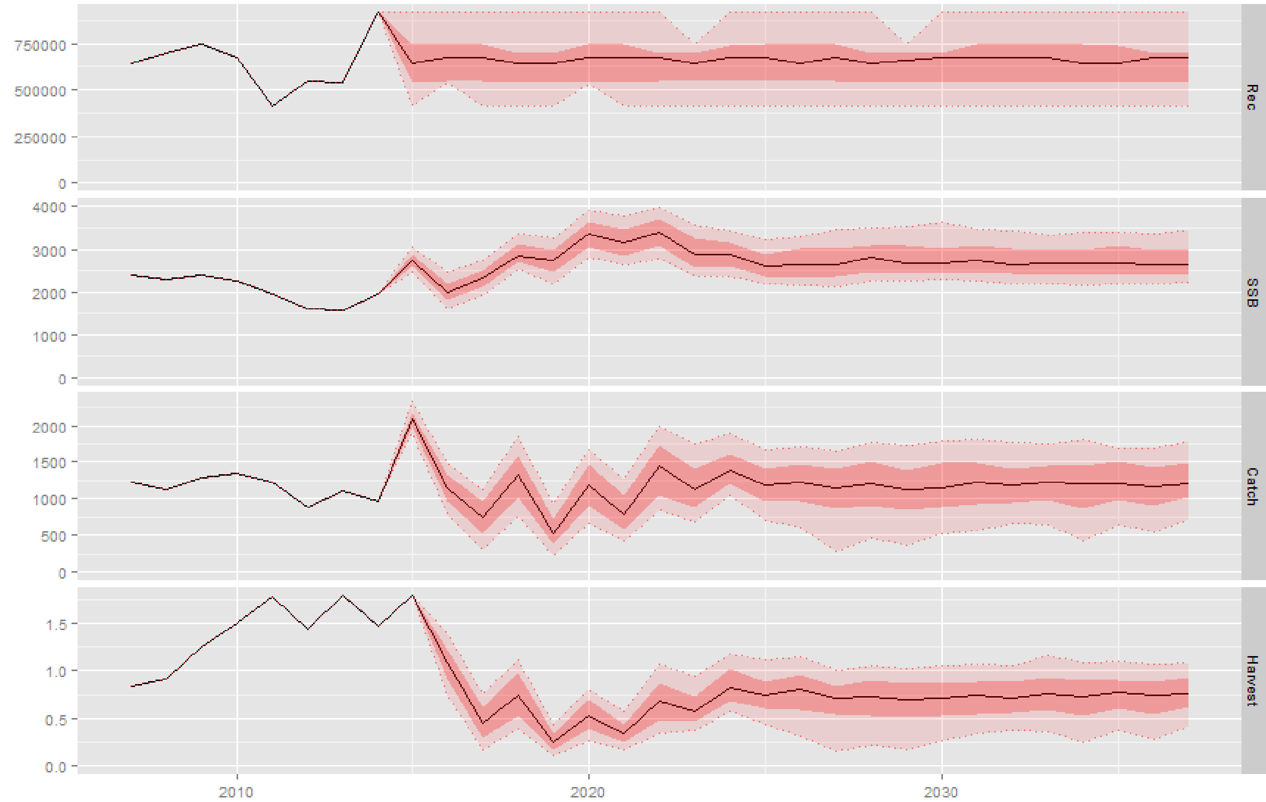


Figure 5.2.10.14.1. Deep-water rose shrimp in GSA 18. Management Strategy Evaluation.

5.2.11 STOCK ASSESSMENT OF DEEP-WATER ROSE SHRIMP IN GSA 19

Stock Identification

Due to a lack of information about the structure of deep-water rose shrimp population, this stock was assumed to be confined within the boundaries of the GSA 19.

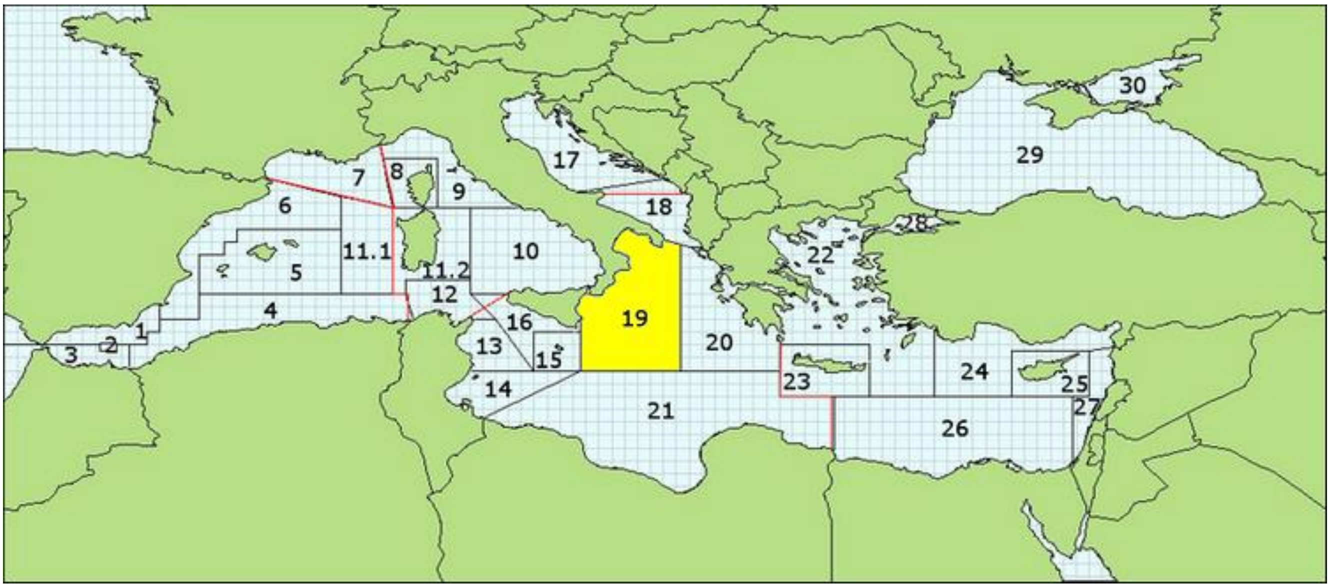


Figure 5.2.11.1. Geographical location of GSA 19.

Growth

Growth parameters (Linf= 46.0, k= 0.6; to= -0.2, sex combined) and length-weight relationship parameters (a=0.0043, b=2.376) were estimated within the DCF 2015 for sexes combined and carapace length expressed in mm. These parameters were used in the assessment.

Maturity

In GSA 19 the deep-water rose shrimp showed an extended reproductive period between late spring and autumn. The highest percentage of mature females was recorded during autumn.

The maturity ogive Fig. 5.2.11.3.1 was obtained in DCF 2008 framework from a maximum likelihood procedure applied grouping as mature individuals belonging to the maturity stage 2b-2e (according to the MEDITS maturity scale).

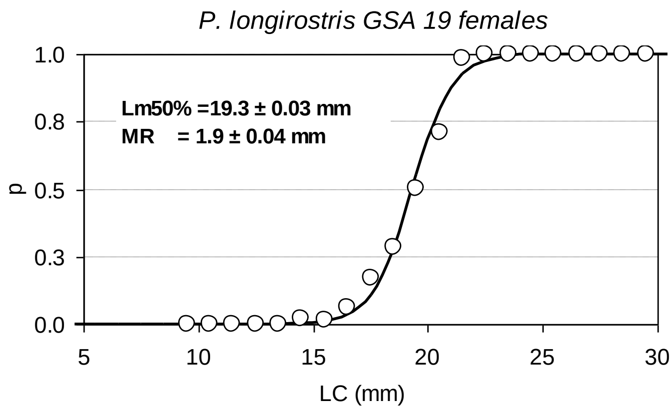


Figure 5.2.11.3.1. Deep-water rose shrimp GSA 19. Maturity ogive from DCF 2008 (MR indicates the difference $Lm_{75\%}$-$Lm_{25\%}$).

Natural mortality

Fisheries

5.2.11.1.1 General description of the fisheries

In the north-western Ionian Sea, fishing occurs from coastal waters to 700–750 m. The most important demersal resources in the north-western Ionian Sea are represented by the red mullet (*Mullus barbatus*) on the continental shelf, hake (*Merluccius merluccius*), deep-water rose shrimp (*Parapenaeus longirostris*) and Norway lobster (*Nephrops norvegicus*) over a wide bathymetric range and the deep-water red shrimps (*Aristeus antennatus* and *Aristaeomorpha foliacea*) on the slope. Pink shrimp is only targeted by trawlers in this area. Gallipoli, Taranto, Crotone and Reggio Calabria represent the most important fisheries in the north-west Ionian Sea, although with a different distribution of the fishing effort.

5.2.11.1.2 Management regulations applicable in 2015

Management regulations are based on technical measures, closed number of fishing licenses for the fleet and area limitation (distance from the coast and depth). In order to limit the over-capacity of fishing fleet, the Italian fishing licenses have been fixed since the late eighties. Other measures on which the management regulations are based regard technical measures (mesh size) and minimum landing sizes (EC 1967/06).

In the GSA 19 the fishing ban has not been mandatory along the time, and from one year to the other it was adopted on a voluntary basis by fishers, whilst in the last years it was mandatory.

Porto Cesareo MPA was permanently established in 1997 (Decree of Ministry of Environment of 12.12.1997; G.U. n. 45 del 24/02/1998). Porto Cesareo MPA is delimited by Punta Prosciutto and Torre dell'Inserraglio and its surface is 16.654 hectares. The MPA is divided in three zones with different level of protection, from total to partial.

Since June 2010 the rules implemented in the EU regulation (EC 1967/06) regarding the cod-end mesh size and the operative distance of fishing from the coasts are enforced.

5.2.11.1.3 Landings

Available landing data are from DCF. EWG 15-16 received landings data for GSA 19 from 2004 to 2014. These landings are listed in Table 5.2.11.5.3.1. and are shown in Figure 5.2.11.5.3.1.

Landings show a decreasing tendency along the period, with an important reduction on landings from 2007 to 2014.

Table 5.2.11.5.3.1. Deep-water rose shrimp in GSA 19. Annual landings (tons) from 2004 to 2014.

gear	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
OTB	1170.1	1243.1	1244.6	607.5	785	767.3	715.6	592.9	487.6	334.4	421.5

5.2.11.1.4 Discards

The proportion of the discards of deep-water rose shrimp in the GSA 19 was generally low (less than 7%). Discards data of 2006, 2009, 2010, 2011 and 2012 were available and are listed in the Table 5.2.11.5.4.1. Due to the lack of landings in 2007 and 2008 (they were not mandatory for DCF) total values were reconstructed using the mean landings/discards proportion in two contiguous years (2009 and 2010).

Table 5.2.11.5.4.1. Deep-water rose shrimp in GSA 19. Discards data (tons) over the period considered.

OTB	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Discards			18.96			54.5	36.1	13.5	8	20.4	8.9
Catch %			1.5			7.1	5.0	2.3	1.6	6.1	2.1

The length frequency distributions of landings and discards as reported by the DCF 2015 have been sliced with a knife function (LFDA) by age (Table 5.2.11.5.4.2).

Table 5.2.11.5.4.2. Deep-water rose shrimp in GSA 19. Landings and discards data (tons) sliced by age (LFDA). (In red years for which discard have been reconstructed).

DPS_LFDA landings

AGE	2007	2008	2009	2010	2011	2012	2013	2014
0	68816.91	96103.45	104214.3	76190.55	74859.96	59302.72	41483.64	64719.04
1	28666.05	35917.79	32098.95	35750.78	25396.47	18526.13	13195.94	16454.2
2	243.388	740.356	730.463	1519.363	1567.441	567.421	325.203	313.3
3	0	18.016	3.858	60.326	1.343	24.713	1.981	4.01

DPS_LFDA discards

AGE	**2007**	**2008**	2009	2010	2011	2012	2013	2014
0	12567.18	17550.18	25947.94	15152.36	5837.825	2943.665	7050.738	3193.19
1	109.5873	137.3099	108.724	153.313	85.359	17.324	29.512	10.499
2	0.058503	0.177959	0.347	0.009	0.079	0	0	0

5.2.11.1.5 Fishing effort

The trends in fishing effort by year as reported for the GSA 19 through the 2015 DCF official data call are listed in table 5.2.11.5.5.1. In figure 5.2.11.5.5.1 the trend of the main fleet (OTB) targheting the deep-water rose shrimp is reported.

Table 5.2.11.5.5.1. Nominal effort in the GSA 19, from 2004 to 2014 (DCF 2015).

GSA 19	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
FPO			378783	56433	54555	43143	232619	306303	284107	166250	270169	153144	133392
GND			728507	222428	505277	270396	239342	256486	610146	527523	559590	53176	115664
GNS			797996	1197159	1402176	1473754	1275650	1441596	1813781	1705748	1627697	2394257	2065333
GTR	4669873	9192254	2742293	2115507	1106682	925004	1131865	1653130	1896850	1777574	1590170	3379761	2358945
LLD			5367540	6420870	4414699	4431347	5603064	3987741	4245026	2453384	3916244	3885256	3835537
LLS			1143710	861956	870853	1062369	620865	679391	852696	1056634	1307624	2054032	1763634
LTL				111047	155819	23117	33950				0		
OTB	5125805	5002396	5875474	4181999	6770477	5312380	5350926	6361017	6645697	6832229	6382671	6128857	6027003
OTM										9781	317792		
PS	978457	1629677	1564124	1652286	896924	897398	1452553	791024	765213	741056	1014674	615055	511171
PTM			0		11424					13898			

OTB nominal effort

2002	5125805
2003	5002396
2004	5875474
2005	4181999
2006	6770477
2007	5312380
2008	5350926
2009	6361017
2010	6645697
2011	6832229
2012	6382671
2013	6128857
2014	6027003

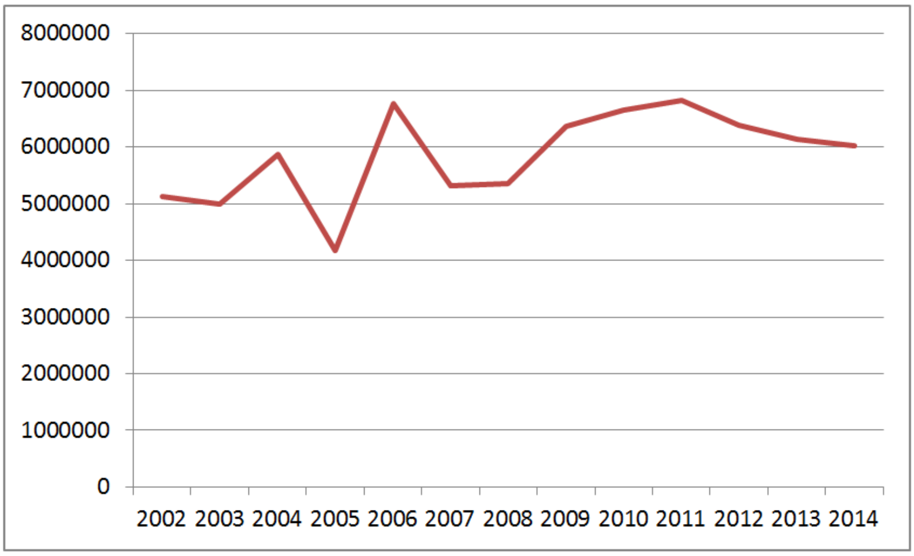


Figure 5.2.11.5.5.1. Effort for OTB in the GSA 19, from 2004 to 2012 (DCF 2015).

Scientific surveys

5.2.11.1.6 Survey #1 (MEDITS)

5.2.11.1.6.1 Methods

Based on the DCR data call, abundance and biomass indices were recalculated. In GSA 19 the following number of hauls was reported per depth stratum (Tab. 5.2.11.6.1.1.1).

Table 5.2.11.6.1.1.1. Number of hauls per year and depth stratum in GSA 19, 1994-2012.

STRATUM	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
GSA19_010-050	9	9	9	9	9	9	9	9	9	9	9	9	9	8	9	9	9	9	9	9	9
GSA19_050-100	8	8	8	8	8	8	8	8	8	8	8	8	8	9	8	8	8	8	8	8	8
GSA19_100-200	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
GSA19_200-500	16	15	15	15	15	15	15	15	14	14	14	15	14	14	14	14	14	14	14	14	14
GSA19_500-800	31	32	32	32	32	32	32	32	29	29	29	28	29	29	29	29	29	29	29	29	29

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Catches by haul were standardized to 60 minutes hauling duration. Hauls noted as valid were used only, including stations with no catches (zero catches are included).

The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

$Yst = \Sigma (Yi*Ai) / A$

$V(Yst) = \Sigma (Ai^2 * si^2 / ni) / A^2$

Where:

A=total survey area

Ai=area of the i-th stratum

si=standard deviation of the i-th stratum

ni=number of valid hauls of the i-th stratum
n=number of hauls in the GSA
Yi=mean of the i-th stratum
Yst=stratified mean abundance
V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as standard deviation.

It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution, quasi-poisson. Indeed, data may be better modelled using the idea of conditionality and the negative binomial (e.g. O'Brien et al. (2004)). Length distributions represented the number of individuals per km^2 (Cochran, 1977).

5.2.11.1.6.2 Geographical distribution

Nursery areas of deep-water rose shrimp were frequently detected on the shelf and shelf break between Otranto and Santa Maria di Leuca, offshore Torre Ovo, around the Amendolara Bank, in the Gulf of Squillace, offshore Punta Stilo and Siracusa. However, the more persistent nursery area was identified on the shelf between Otranto and Santa Maria di Leuca.

5.2.11.1.6.3 Trends in abundance and biomass

Fishery independent information regarding the state of deep-water rose shrimp in GSA 19 was derived from the international survey MEDITS and was compiled during STECF 15-16. Table 5.2.11.6.1.3.1.1 displays the estimated trend with coefficient of variation in deep-water rose shrimp abundance (N/km^2) and biomass (kg/km^2) in GSA 19 (0-800 m) for the entire time series (1994-2014). Abundance indices show an increasing pattern with remarkable peaks in 1997, 2009 and 2013. Figure 5.2.11.6.1.3.1.1 is the plot of abundance indices with the relative interval of confidence.

Table 5.2.11.6.1.3.1.1. Deep-water rose shrimp in GSA 19. Abundance (N/km^2) and biomass (kg/km^2) indices.

year	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
DI (0-800)	719	1044	811	1108	1506	713	547	520	959	1375	1031	1160	1452	944	1678	2307	2097	1339	1566	2199	1554
cv DI (%)	25	0.24	0.23	0.27	0.3	0.31	0.35	0.26	0.2	0.24	0.17	0.23	0.26	0.16	0.26	0.21	0.16	0.25	0.19	0.22	0.23
BI (0-800)	5.5	8.0	4.4	6.8	9.3	3.8	3.3	3.3	5.9	7.1	7.7	6.8	7.1	4.4	8.6	12.1	10.9	6.9	8.8	10.0	7.2
cv BI (%)	19.7	0.24	0.23	0.27	0.3	0.31	0.35	0.26	0.2	0.24	0.17	0.23	0.26	0.16	0.26	0.21	0.16	0.25	0.19	0.22	0.23

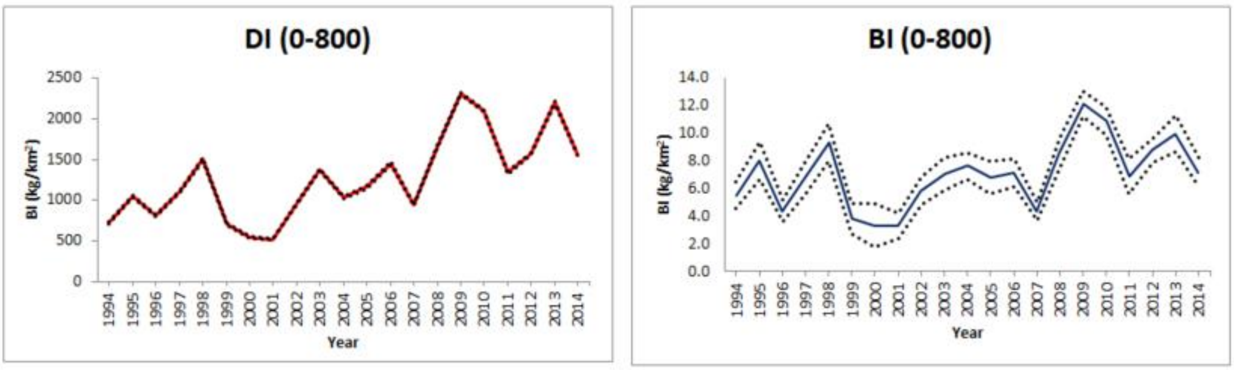


Figure 5.2.11.6.1.3.1.1. Deep-water rose shrimp in GSA 19. Trend in abundance and biomass indices.

5.2.11.1.6.4 Trends in abundance by length or age

The following figure (Figure 5.2.11.6.1.4.1) display pink shrimp abundance by size in GSA 19 over the whole time series (1994-20014).

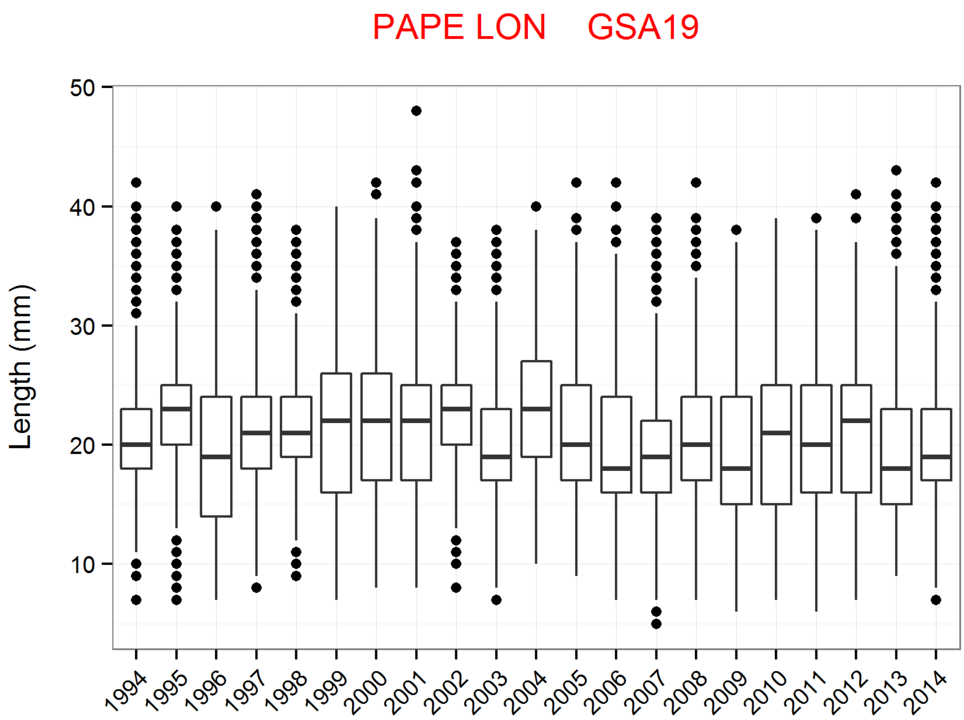


Figure 5.2.11.6.1.4.1. Deep-water rose shrimp in GSA 19. Box plot of abundance indices by size, 1994-2014.

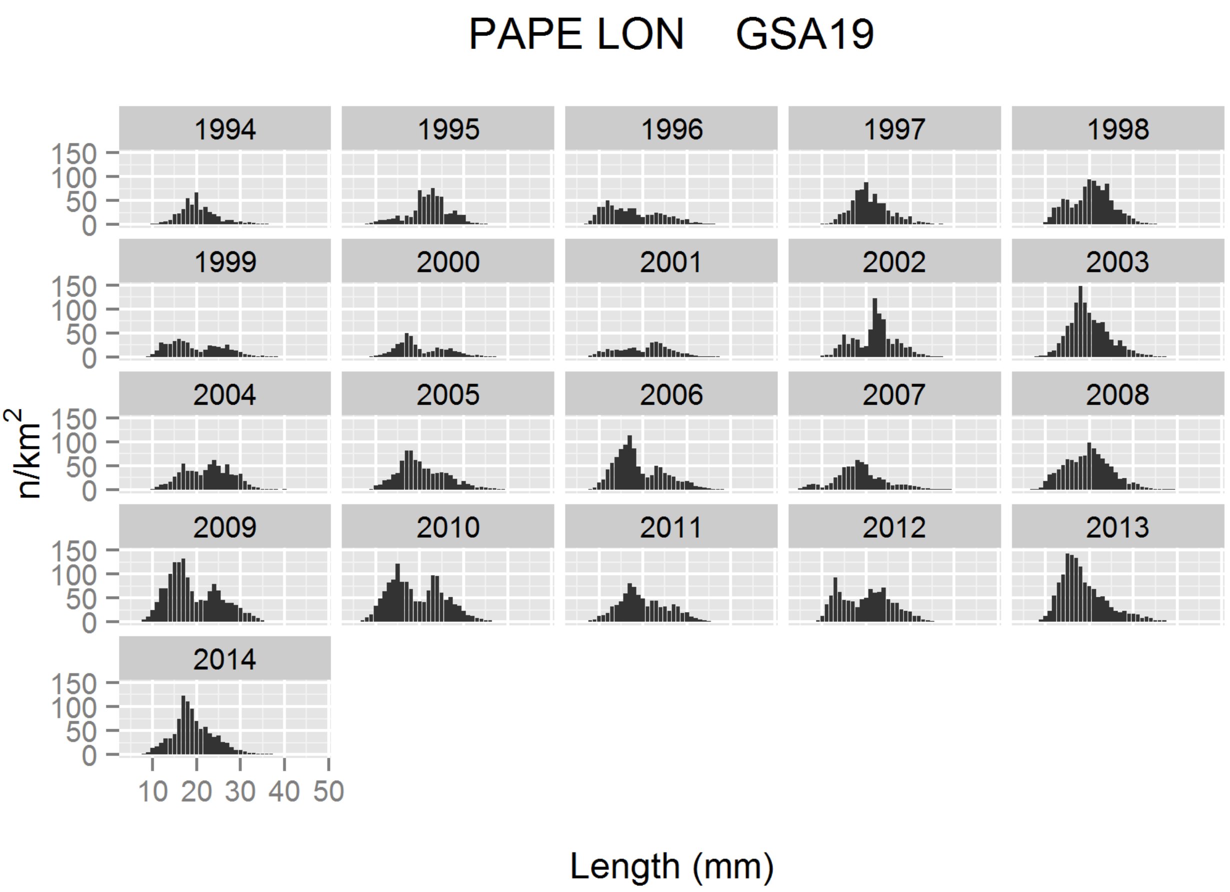


Figure 5.2.11.6.1.4.1. Deep-water rose shrimp in GSA 19. Abundance indices by size, 1994-2014.

Stock Assessment

EWG 15-16 applied the Extended Survivors Analysis (XSA – Darby and Flatman, 1994) to commercial landings and MEDITS survey data.

5.2.11.1.7 Methods

The data provided to EWG has been considered covering more than the mean life span of the species, allowing to make an attempt of stock assessment with XSA method. XSA was applied using the landing structures at age and the data of MEDITS survey from 2007 to 2014.

5.2.11.1.8 Input data

For the assessment of deep-water rose shrimp stock in GSA19 the DCF official data on the age structure and landing of commercial catch have been used. A sex combined analysis was carried out using the following growth parameters:

CL_{∞} = 46 mm, K= 0.6, t_0= -0.2; length-weight relationship: a=0.0043, b=2.376.

Catch numbers at age were derived from the DCF annual size distributions using the LFDA (FAO package) algorithm to slice the LFDs. For older individuals a 3+ group has been used.

The maturity at age has been derived by the maturity at length by age slicing procedure.

The natural mortality has been calculated using PRODBIOM method (Abella, 1998).

The other input data are reported in the tables below (Table 5.2.11.7.2.1).

Table 5.2.11.7.2.1 Input parameters for XSA

```
### TUNING
#  Medits
   year
age  2007  2008   2009  2010  2011  2012   2013  2014
  0 485.5 765.7 1002.0 906.4 566.3 661.3 1092.5 758.2
  1 116.3 284.4  431.1 463.8 254.0 353.3  247.7 208.4
  2   7.8   8.8   27.9  22.2  11.2  13.1   31.9   8.4
  3   0.5   0.7    0.5   0.6   0.3   0.5    1.7   0.8

### initial settings
      min       max plusgroup   minyear   maxyear   minfbar   maxfbar
        0         3         3      2007      2014         0         2

### Mortality and Maturity vectors@age
             0    1   2    3
maturity  0.23 1.00 1.0 1.00
mortality 1.41 0.81 0.7 0.65

### Mean Weight@age (kg) in stock, catch, landings
   year
age 2007   2008   2009   2010   2011   2012   2013   2014
  0 0.0026 0.0026 0.0025 0.0025 0.0027 0.0029 0.0029 0.0023
  1 0.0109 0.0108 0.0108 0.0104 0.0111 0.0112 0.0112 0.0111
  2 0.0180 0.0181 0.0181 0.0171 0.0182 0.0181 0.0181 0.0192
  3 0.0226 0.0228 0.0230 0.0214 0.0229 0.0226 0.0226 0.0247

### catch in weight (ton) by year
     year
age   2007   2008   2009   2010   2011   2012   2013   2014
  all 710.41 917.96 821.83 751.74 606.32 495.58 354.84 430.40

### Catch at age matrix (numbers in thousands)
   year
age 2007   2008   2009   2010   2011   2012   2013   2014
  0  82648 110505 101616  83149  62478  52336  54622  55458
  1  29223  35056  25144  32683  19729  15591  14884  13445
  2    247    720    571   1383   1214    477    366    256
  3      0     18      3     55      1     21      2      3
```

5.2.11.1.9 Results

A sensitivity analysis have been performed to select the best parameters for XSA.
Several different runs (n=216) have been carried out, changing all the combination of rage (-1 to 1, step of 1), qage (0 to 3, step of 1), shk.ages (1 to 3, step of 1) and fse (0.5 to 3, setp of 0.5).
From an overall view of the residuals of the different runs (figure 5.2.11.7.3.1) we exclude those settings that gives values greater than 2, and we analyse the best 36 runs (rage=-1, qage>0, fse>1) obtained more in detail.

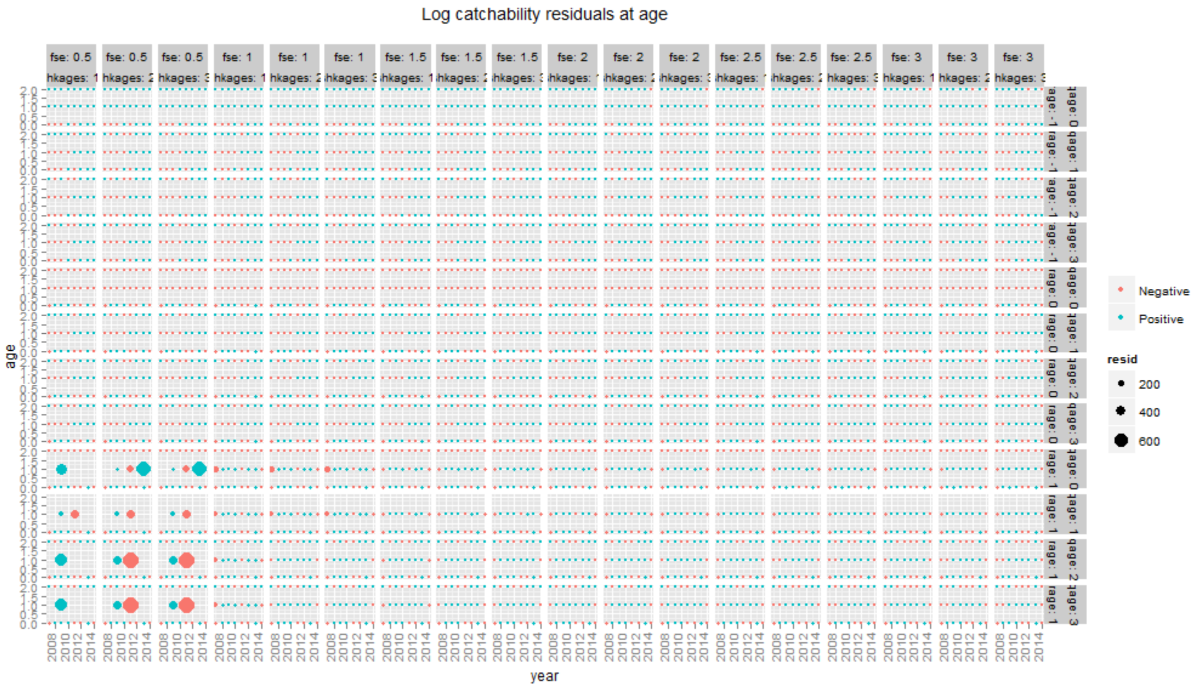


Figure 5.2.11.7.3.1. Deep-water rose shrimp in GSA 19. Log residuals of the all XSA runs.

On the basis of the settings that minimized the residuals (table 5.2.11.7.3.1 and figures 5.2.11.7.3.2 and 5.2.11.7.3.3) and of the sensitivity analysis (figures 5.2.11.7.3.4), the XSA settings for the final assessment have been defined (table 5.2.11.7.3.2).

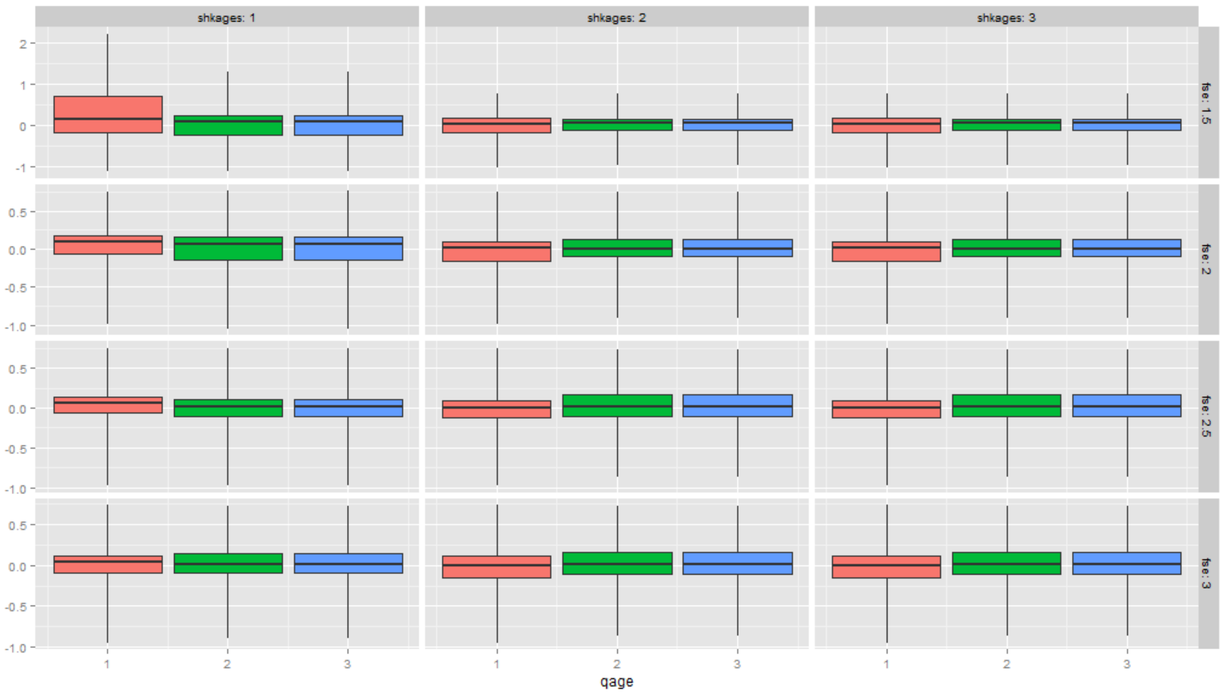


Figure 5.2.11.7.3.2. Deep-water rose shrimp in GSA 19. Boxplot of the residuals of the best XSA runs (n=36, rage=-1, qage>0, fse>1).

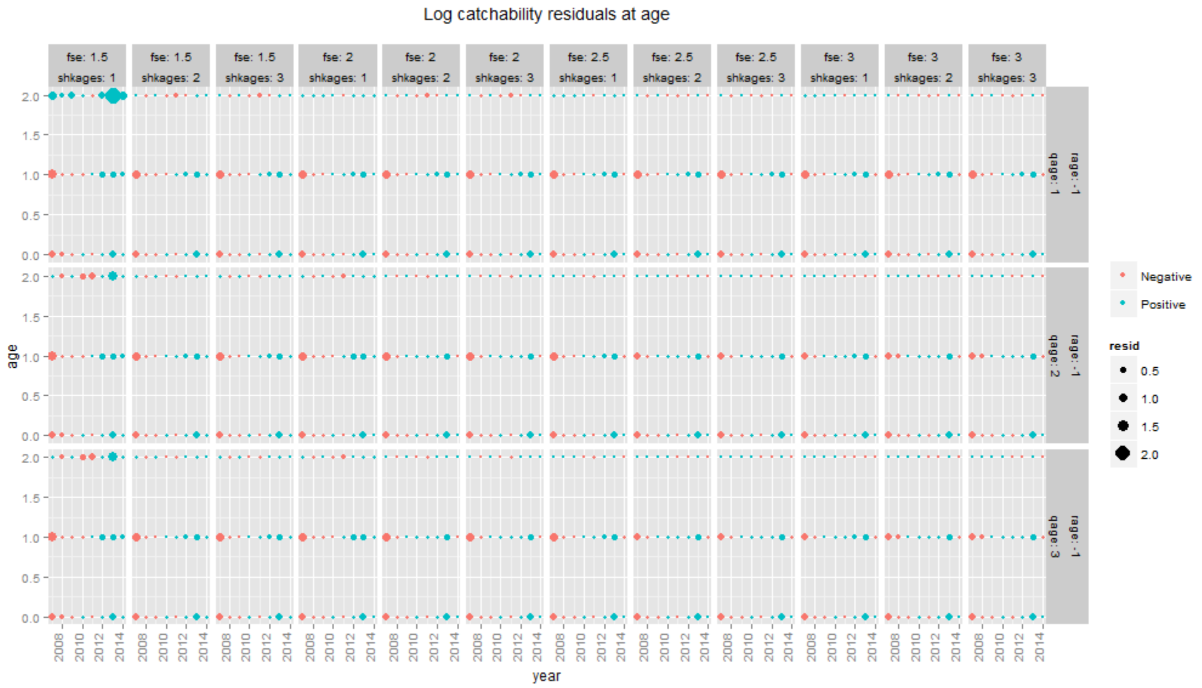
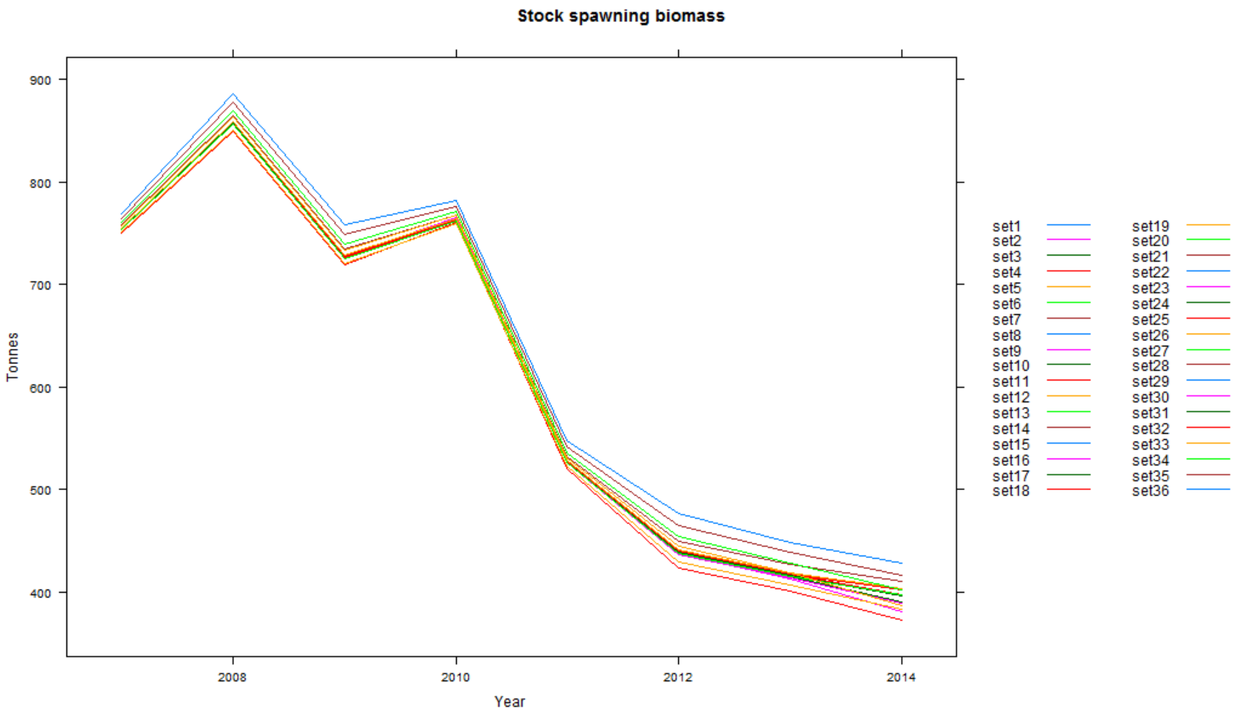


Figure 5.2.11.7.3.3. Deep-water rose shrimp in GSA 19. Log residuals of the best XSA runs (n=36, rage=-1, qage>0, fse>1).

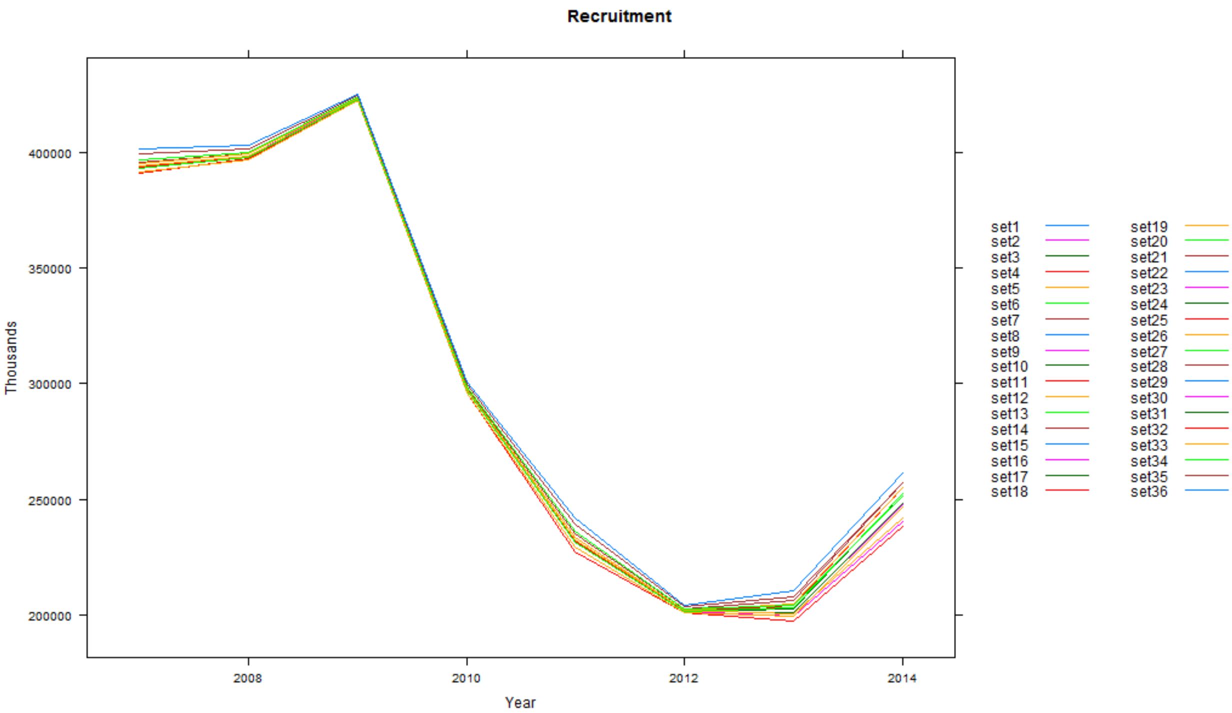
Table 5.2.11.7.3.1. Deep-water rose shrimp in GSA 19. XSA run comparison: minimum, lower-hinge, median, upper-hinge, maximum, absolute mean and mean for the residuals of the the best XSA runs.

set number	shkages	fse	rage	qage	min	H_{lower}	median	H_{upper}	max	abs mean	mean
1	1	1.5	-1	1	-1.128	-0.180	0.143	0.703	2.192	0.515	0.246
2	1	1.5	-1	2	-1.127	-0.245	0.071	0.238	1.282	0.405	-0.014
3	1	1.5	-1	3	-1.127	-0.245	0.071	0.238	1.282	0.405	-0.014
4	1	2.5	-1	1	-0.967	-0.057	0.058	0.135	0.745	0.233	0.012
5	1	2.5	-1	2	-0.972	-0.105	0.013	0.105	0.743	0.221	-0.011
6	1	2.5	-1	3	-0.972	-0.105	0.013	0.105	0.743	0.221	-0.011
7	1	2	-1	1	-0.993	-0.063	0.095	0.168	0.755	0.249	0.025
8	1	2	-1	2	-1.051	-0.145	0.063	0.162	0.759	0.263	-0.011
9	1	2	-1	3	-1.051	-0.145	0.063	0.162	0.759	0.263	-0.011
10	1	3	-1	1	-0.950	-0.095	0.045	0.119	0.737	0.227	0.005
11	1	3	-1	2	-0.895	-0.098	0.009	0.142	0.728	0.215	-0.010
12	1	3	-1	3	-0.895	-0.098	0.009	0.142	0.728	0.215	-0.010
13	2	1.5	-1	1	-1.020	-0.196	0.018	0.156	0.760	0.262	-0.031
14	2	1.5	-1	2	-0.973	-0.130	0.052	0.126	0.757	0.245	-0.011
15	2	1.5	-1	3	-0.973	-0.130	0.052	0.126	0.757	0.245	-0.011
16	2	2.5	-1	1	-0.964	-0.128	-0.005	0.096	0.744	0.229	-0.023
17	2	2.5	-1	2	-0.871	-0.105	0.011	0.166	0.729	0.214	-0.010
18	2	2.5	-1	3	-0.871	-0.105	0.011	0.166	0.729	0.214	-0.010
19	2	2	-1	1	-0.988	-0.155	0.019	0.094	0.754	0.238	-0.027
20	2	2	-1	2	-0.905	-0.099	0.005	0.127	0.743	0.217	-0.010
21	2	2	-1	3	-0.905	-0.099	0.005	0.127	0.743	0.217	-0.010

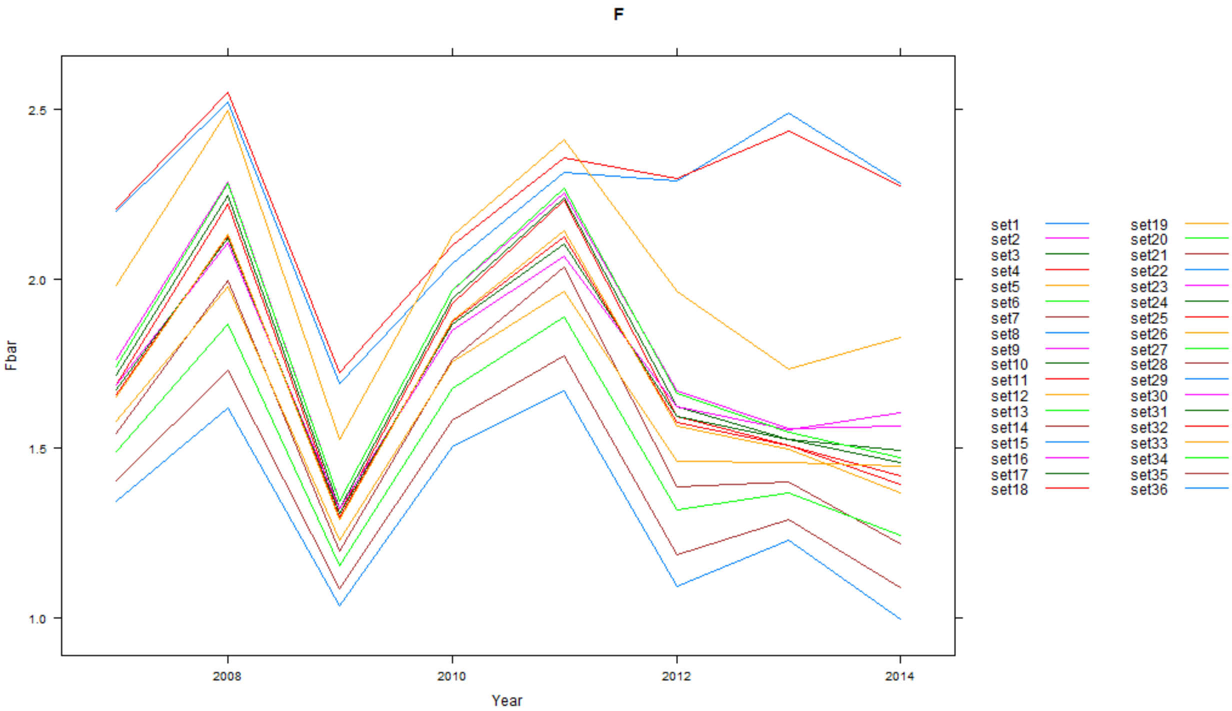
set number	shkages	fse	rage	qage	min	H_{lower}	median	H_{upper}	max	abs mean	mean
22	2	3	-1	1	-0.949	-0.149	-0.008	0.110	0.736	0.226	-0.021
23	2	3	-1	2	-0.867	-0.104	0.011	0.165	0.718	0.214	-0.010
24	2	3	-1	3	-0.867	-0.104	0.011	0.165	0.718	0.214	-0.010
25	3	1.5	-1	1	-1.020	-0.196	0.018	0.156	0.760	0.262	-0.031
26	3	1.5	-1	2	-0.973	-0.130	0.052	0.126	0.757	0.245	-0.011
27	3	1.5	-1	3	-0.973	-0.130	0.052	0.126	0.757	0.245	-0.011
28	3	2.5	-1	1	-0.964	-0.128	-0.005	0.096	0.744	0.229	-0.023
29	3	2.5	-1	2	-0.871	-0.105	0.011	0.166	0.729	0.214	-0.010
30	3	2.5	-1	3	-0.871	-0.105	0.011	0.166	0.729	0.214	-0.010
31	3	2	-1	1	-0.988	-0.155	0.019	0.094	0.754	0.238	-0.027
32	3	2	-1	2	-0.905	-0.099	0.005	0.127	0.743	0.217	-0.010
33	3	2	-1	3	-0.905	-0.099	0.005	0.127	0.743	0.217	-0.010
34	3	3	-1	1	-0.949	-0.149	-0.008	0.110	0.736	0.226	-0.021
35	3	3	-1	2	-0.867	-0.104	0.011	0.165	0.718	0.214	-0.010
36	3	3	-1	3	-0.867	-0.104	0.011	0.165	0.718	0.214	-0.010



A



B



C

Figure 5.2.11.7.3.4. Deep-water rose shrimp in GSA 19. XSA sensitivity analysis on a) SSB, b) Recruitment and c) F estimations.

The final assessment have been run with the following settings for XSA:
- Catchability independent on stock size for all ages (rage= -1);
- Catchability independent of age for ages > 2 (qage=2);
- S.E. of the mean to which the estimates are shrunk was 1.5 (fse= 1.5);
- Minimum standard error for population estimates derived = 0.300.

Table 5.2.11.7.3.2. Deep-water rose shrimp in GSA 19. XSA settings for the final assessment.

Fbar	fse	rage	qage	shk.yrs	shk.age
0-2	1.5	-1	2	3	2

The log-catchability residuals of the assessment are listed (Table 5.2.11.7.3.3) and plotted (figure 5.2.11.7.3.5). The residuals do not show any trend and are very small.

Table 5.2.11.7.3.3. Deep-water rose shrimp in GSA 19. Log-catchability residuals of XSA.

```
### Log catchability residuals of XSA
   year
age 2007      2008      2009      2010      2011      2012      2013      2014
  0 -0.886672 -0.275313 -0.162725  0.193663 -0.064597  0.210882  0.756707  0.094489
  1 -0.973031 -0.252950 -0.055733  0.049842  0.102284  0.332190  0.537423  0.121011
  2  0.100843 -0.097656  0.091663 -0.046180 -0.257901  0.029602  0.130485  0.054534
```

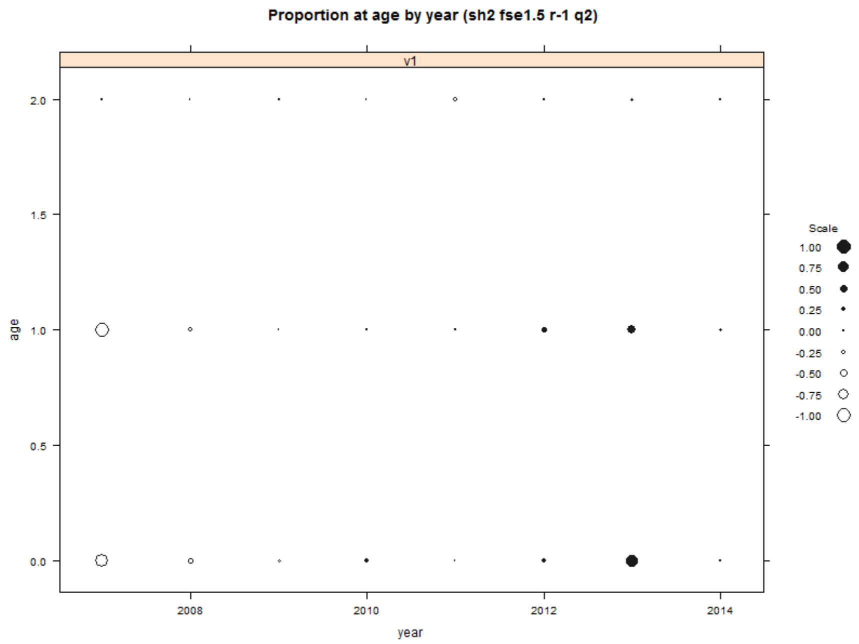


Figure 5.2.11.7.3.5. Deep-water rose shrimp in GSA 19. Bubble pot of residuals of the final XSA model.

The retrospective was carried out and the time series of analysis shows a decreasing signal for SSB also truncating one, two or three years. Moreover, the same global decreasing shape for F is reconstructed in all the cases (Figure 5.2.11.7.3.6).

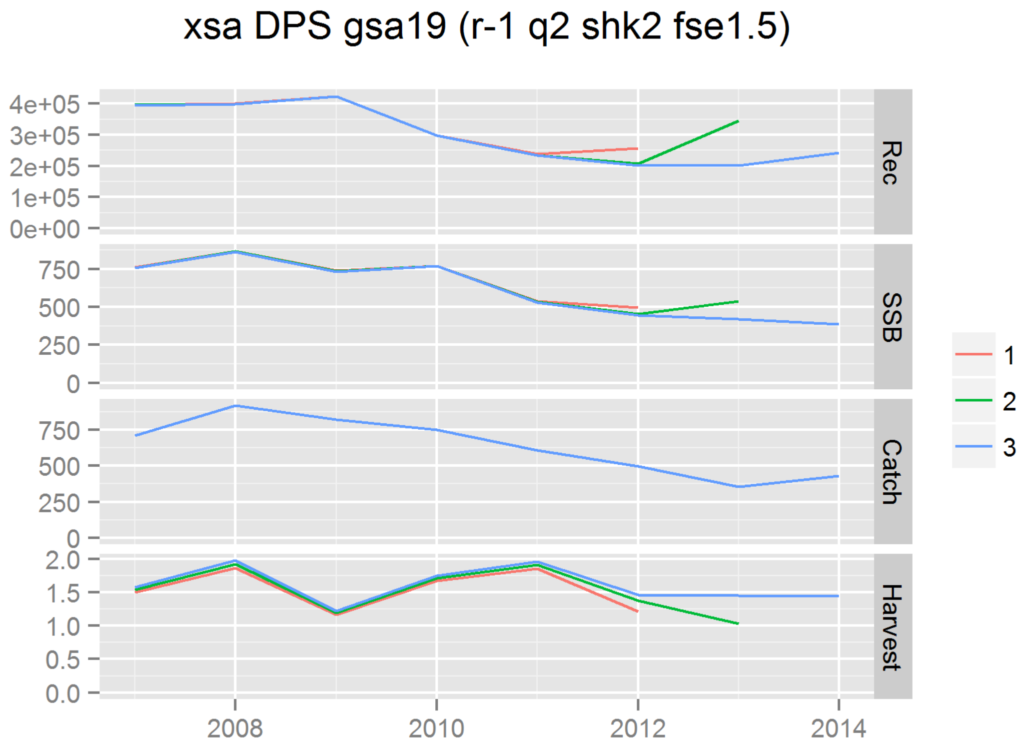


Figure 5.2.11.7.3.6. Deep-water rose shrimp in GSA 19. Retrospective analysis (XSA) results.

The stock overview produced by XSA is reported below in the table 5.2.11.7.3.4 and in the figure 5.2.11.7.3.7. The results obtained with XSA method showed a decreasing pattern in SSB. Recruitment shows a global decrease until 2012 and a pick in 2009. The F shows a decrease in time from 1.98 in 2009 to 1.45 in 2014.

Table 5.2.11.7.3.4. Deep-water rose shrimp in GSA 19. XSA summary, fishing mortality and stock in numbers (thousands).

```
### XSA summary
          2007      2008      2009      2010      2011      2012      2013      2014
ssb     757.50    863.00    733.20    768.00    531.70    444.70    419.20    386.40
fbar      1.58      1.98      1.23      1.76      1.96      1.46      1.46      1.45
rec  395068.00 399270.00 423861.00 297779.00 233323.00 202064.00 200510.00 241922.00
catch   710.40    918.00    821.80    751.70    606.30    495.60    354.80    430.40

### Fishing mortality by year estimated with XSA
   year
age 2007 2008 2009 2010 2011 2012 2013 2014
  0 0.55 0.82 0.66 0.83 0.78 0.74 0.80 0.62
  1 2.89 2.90 2.11 2.52 2.74 2.26 3.01 2.50
  2 1.30 2.21 0.91 1.91 2.37 1.38 0.56 1.22
  3 1.30 2.21 0.91 1.91 2.37 1.38 0.56 1.22

### Stock in numbers (thousands) estimated by age and year
   year
age     2007     2008     2009     2010     2011     2012     2013     2014
  0 395068.4 399269.8 423860.8 297779.2 233323.3 202063.7 200509.7 241921.8
  1  46393.7  55616.1  42877.6  53273.3  31616.0  26093.2  23473.0  21964.0
  2    481.5   1147.8   1359.6   2303.8   1899.9    906.0   1208.9    514.7
  3      0.2     24.4      6.7     81.0      1.4     35.9      7.0      6.0
```

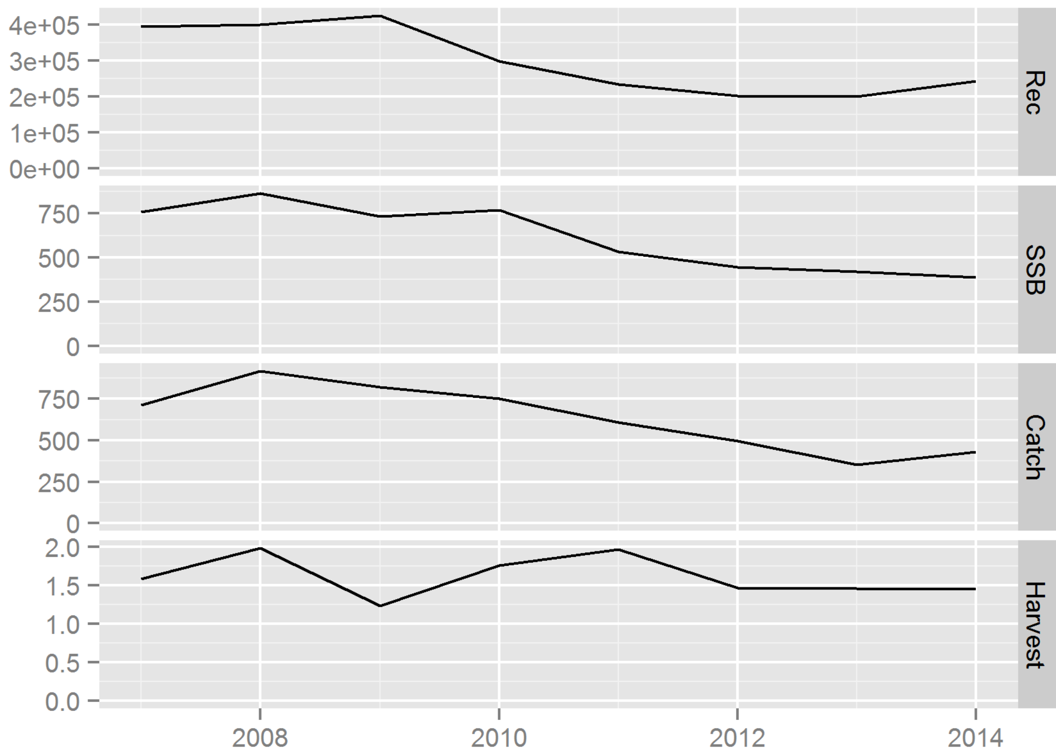


Figure 5.2.11.7.3.7. Deep-water rose shrimp in GSA 19. Estimated recruitment, SSB, F current and yield by year.

Reference points

5.2.11.8.1 *Methods*

The FLBRP package allowed a Yield per recruit analysis and an estimate of some F-based Reference Points as F_{max} and $F_{0.1}$. Yield per Recruit computation was made using R project software and the FLR libraries. The fishing mortality rate corresponding to $F_{0.1}$ in the yield per recruit curve is considered here as a proxy of $F_{MSY.}$

5.2.11.8.2 *Input data*

The input parameters were the same used for the XSA stock assessment and its results.

5.2.11.8.3 *Results*

Reference points were computed using FLBRP package. The estimated value for $F_{0.1}$ is 0.89 that is used as proxy for F_{MSY}.

Data quality

Assessments were performed using the time series as reported by DCF 2015. No major issues have been observed in tha data available form the 2015 official DCF data call.

A sum of products correction was applied to the landings at age matrix.

Landings in 2007 and 2008 (collection was not mandatory by DCF) were reconstructed using the mean landings/discards proportion in two contiguous years (2009-2010).

Row MEDITS data used for this assessment have been provided by JRC.

In 2014 the MEDITS survey was carried out in September.

Short term predictions 2015-2017

5.2.11.8.4 *Method*

A deterministic short term prediction for the period 2015 to 2017 was performed using the FLR routines provided by JRC and based on the results of the XSA stock assessments performed during EWG 15-16.

5.2.11.8.5 *Input parameters*

The input parameters were the same used for the XSA stock assessment and its results. An average of the last three years has been used for weight at age, maturity at age and F at age.

Recruitment (age 0) has been estimated from the population results as the geometric mean of the last 3 years (214009 thousand individuals).

5.2.11.8.6 *Results*

Table 5.2.11.8.6.1. Deep-water rose shrimp in GSA 19. Short term forecast.

Basis: F(2015) = mean (Fbar 0-2 2012-2014)= 1.46; R(2015) = geometric mean of the recruitment of the last 3 years; R = 214009 (thousands); SSB(2014) = 386 t, Catch (2014)= 430 t.

Rationale	Ffactor	Fbar	Catch 2015	Catch 2016	Catch 2017	SSB 2017	Change SSB 2016-2017(%)	Change Catch 2014-2016(%)
Zero catch	0.0	0.00	570	0.0	0.0	940.7	113	-100
High long term yield (F0.1)	0.6	0.89	570	381.4	445.7	560.6	27	-11

Status quo	1.0	1.46	570	523.83	522.52	523.83	-1	22
Different Scenarios	0.2	0.29	570	158.1	236.7	775.2	76	-63
	0.3	0.44	570	222.8	311.2	710.5	61	-48
	0.4	0.58	570	280.1	367.2	654.8	48	-35
	0.5	0.73	570	331.2	409.8	606.5	38	-23
	0.6	0.87	570	377.2	443.0	564.3	28	-12
	0.7	1.02	570	418.9	469.1	527.2	20	-3
	0.8	1.16	570	456.9	490.3	494.2	12	6
	0.9	1.31	570	491.7	507.8	464.8	5	14
	1.0	1.46	570	523.8	522.5	438.4	-1	22
	1.1	1.60	570	553.5	535.3	414.6	-6	29
	1.2	1.75	570	581.1	546.5	393.1	-11	35
	1.3	1.89	570	606.8	556.6	373.5	-15	41
	1.4	2.04	570	630.9	565.8	355.6	-19	47
	1.5	2.18	570	653.4	574.4	339.2	-23	52
	1.6	2.33	570	674.7	582.4	324.2	-26	57
	1.7	2.47	570	694.7	590.0	310.4	-30	61
	1.8	2.62	570	713.5	597.2	297.6	-32	66
	1.9	2.76	570	731.4	604.1	285.9	-35	70
	2.0	2.91	570	748.3	610.8	275.1	-38	74

Medium term predictions

Medium term forecasts were not conducted because no meaningful stock-recruitment relationship was estimated.

5.2.11.8.7 Method

Stock advice

The current F (1.45) is larger than $F_{0.1}$ (0.89), chosen as proxy of F_{MSY} and as the exploitation reference point consistent with high long term yields, which indicates that deep-water pink shrimp in GSA 19 is exploited above F_{MSY}. Catches of deep-water rose shrimp in 2016 consistent with $F_{0.1}$ (0.89) should not exceed 561 tonnes.

Management strategy evaluation

A Management Strategy Evaluation was run to evaluate if the MSY ranges were precautionary. The F_{MSY} ranges were derived using the formula provided by STECF EWG 15-16. F ranges results were F_{upper}=1.21 and F_{lower}=0.59. B_{lim} was estimated as B_{loss}=386.4 (t). $B_{curr(2014)}$=386.4. The figures 5.2.11.8.7.1 and 5.2.11.8.7.2 show the results of the MSE run with two different approaches (XSA and A4A). Unfortunately both the approaches give unconsistent results and cannot be use to determine the probability to fall below B_{lim} at F = F_{upper}.

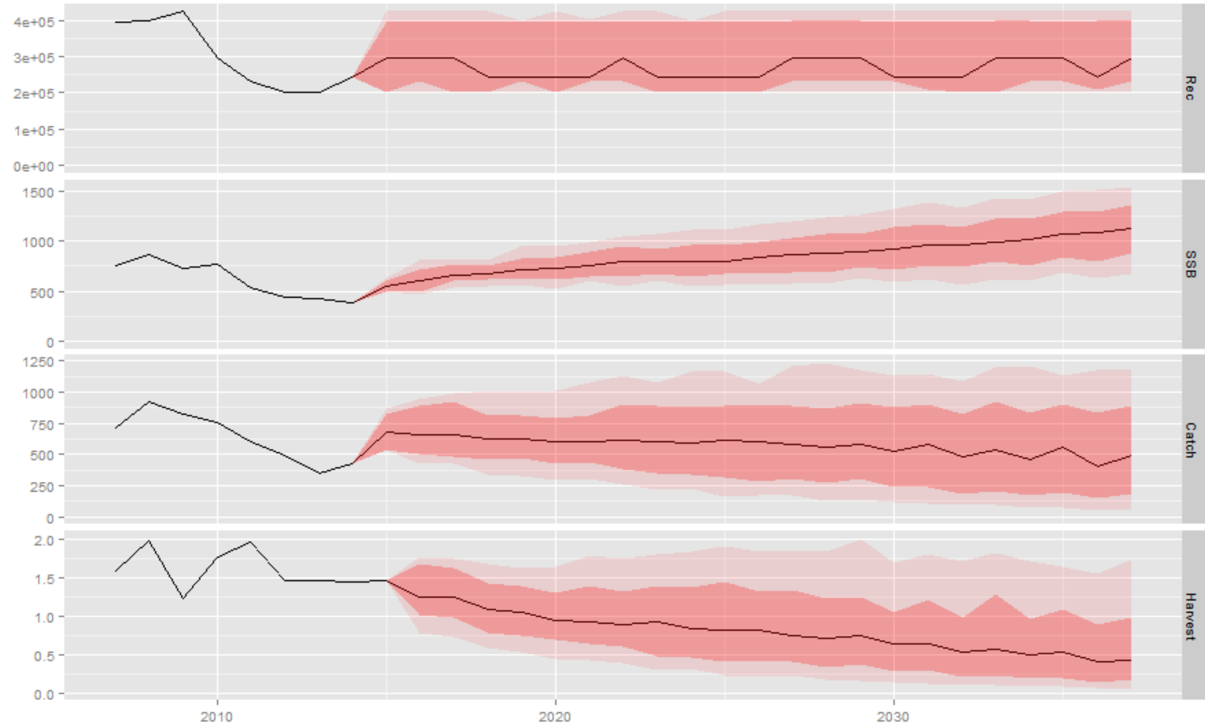


Figure 5.2.11.8.7.1. Deep-water rose shrimp in GSA 19. Management Strategy Evaluation (XSA run).

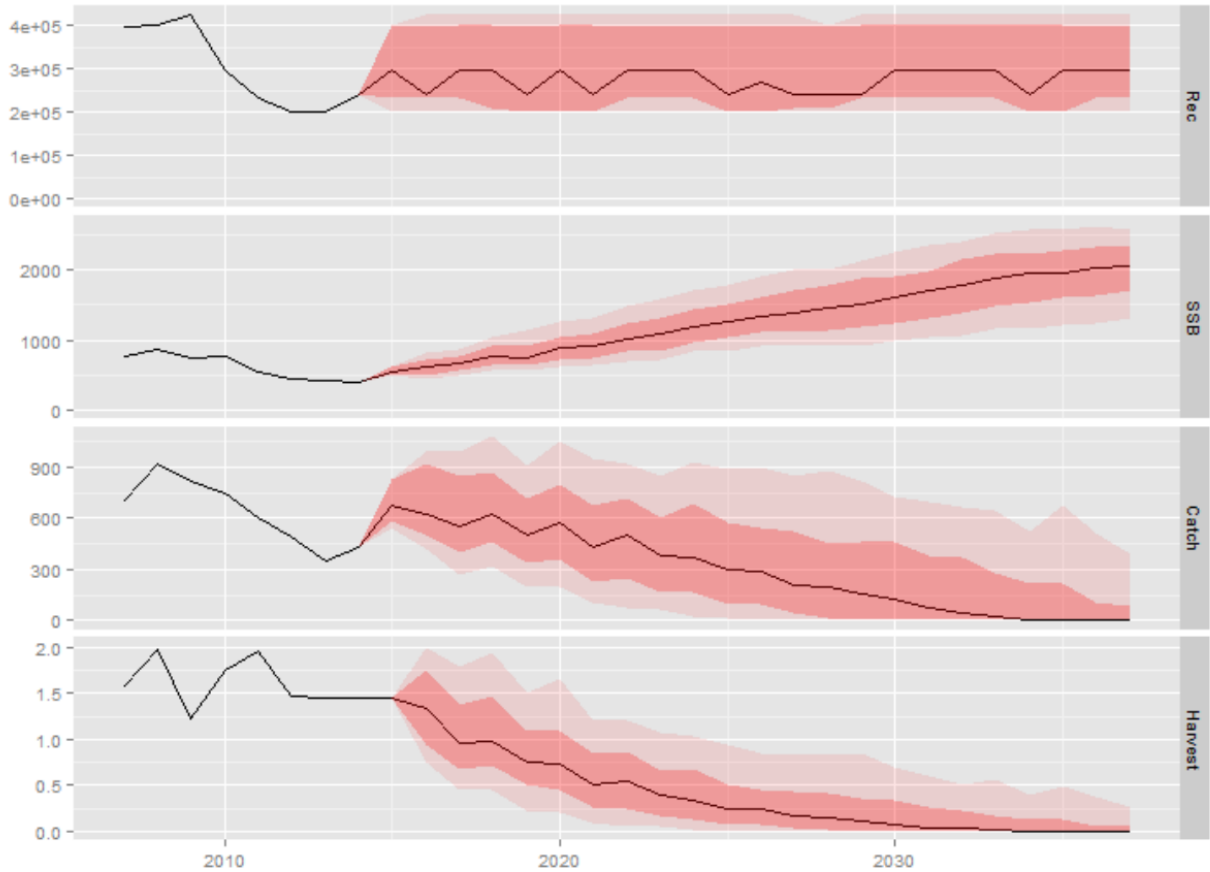


Figure 5.2.11.8.7.2. Deep-water pink shrimp in GSA 19. Management Strategy Evaluation (A4A run).

5.2.12 STOCK ASSESSMENT OF DEEP-WATER ROSE SHRIMP IN GSA 17-18-19

Stock Identification

STECF EWG 15-16 was asked to assess the state of deep-water rose shrimp stocks in the Adriatic and Ionian Sea following two approaches: by single GSAs and GSAs combined. The present assessment will investigate the state of the deep-water rose shrimp stock in GSAs 17, 18, and 19. For the thermophilic and halophilic preference of deep water rose shrimp, the GSA 17 component of the joint stock is considered an expansion of the southern grounds thus the life history traits were assumed to be the same as those of GSA 18.

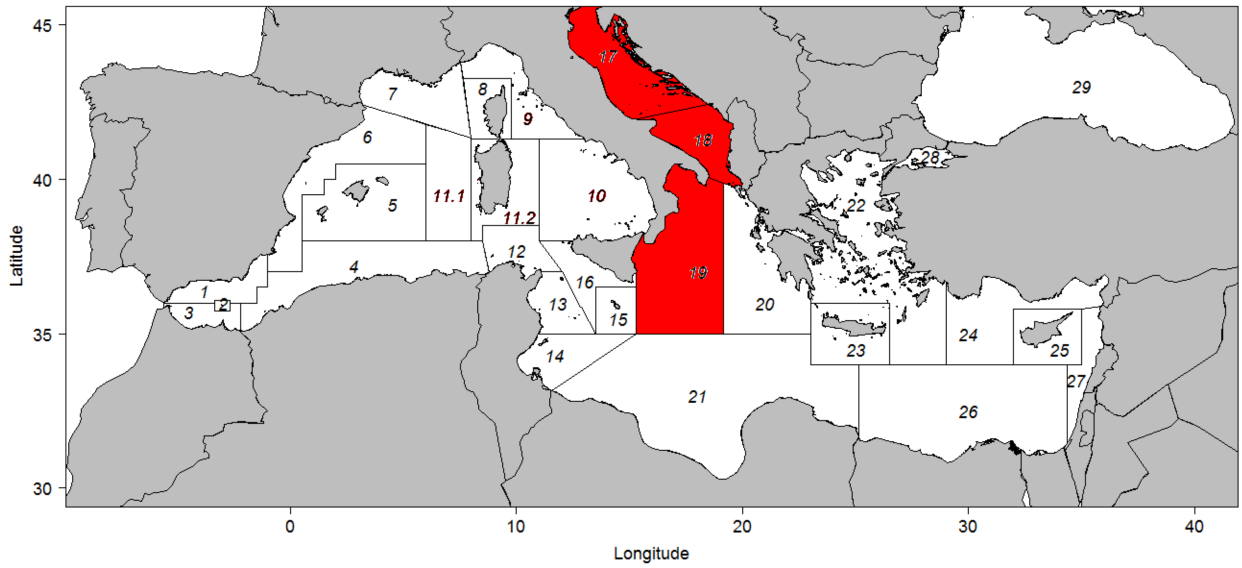


Figure 5.2.12.1.1. Deep.water rose shrimp in GSA 17. Geographical location of GSAs 17, 18, and 19.

Growth

Growth parameters are those used in each GSA (see sections of GSA 18 and GSA 19 assessments).

Maturity

Maturity ogives were taken from each GSA (see sections of GSA 18 and GSA 19 assessments). Combined maturity at age were calculated as a weighted average using the stock numbers.

Natural mortality

Natural mortality was taken from each GSA (see sections of GSA 18 and GSA 19 assessments). Combined natural mortality at age were calculated as a weighted average using the stock numbers.

Fisheries

5.2.12.1.1 General description of the fisheries

Deep-water rose shrimp is targeted mainly by bottom trawlers. See Chapters 5.2.10-5.2.11 in the Report for further details on deep-water rose shrimp fisheries in GSAs 18, and 19.

5.2.12.1.2 Management regulations applicable in 2015

See Chapters 5.2.10-5.2.11 in the Report for management regulations on deep-water rose shrimp fisheries in GSAs 18, and 19.

5.2.12.1.3 Catches

Landing and discards by fleet are described in the following sections 5.2.12.5.4 and 5.2.12.5.5.

5.2.12.1.4 Landings

Landings data were reported to STECF EWG 15-16 through the DCF. In GSAs 17, 18, and 19, the landings come from otter trawls. DCF data prior to 2006 were considered inaccurate, therefore they were not included in the stock assessment. Landings data for GSA 17 were incomplete. Italian landings were present just for 2002, 2003, 2006, 2011, 2013 and 2014. Croatian landings were present just for 2014 in the DCF database because previously there was no obligation to monitor that species. The complete Italian time series of landings was provided by Italian experts. The Croatian time series of landings from 2008 was provided by Croatian experts. Croatian landings for 2007 were assumed to be equal to the landings of 2008. For the Italian landings not in the DCF database, the length frequency distribution of the same year from GSA 18 was applied. For Croatian landings not in DCF the length frequency distribution of the same year from the Croatian MEDITS was applied.

	Croatia	Italy
2007	70.4	70.1
2008	70.4	53.9
2009	136.8	43.8
2010	171.8	64.7
2011	149.1	92.5
2012	162.8	52.8
2013	308.2	84.3
2014	362.7	202.3

Figure 5.2.12.5.4.1. Deep-water rose shrimp in GSA 17. Landings data in tonnes. The landings data present in the DCF database are in green. Croatian landings for 2007 were assumed to be equal to 2008.

For more details on landings and age-structure of landings, please see sections 5.2.10-5.2.11 in this report.

5.2.12.1.5 Discards

Discards data were reported to STECF EWG 15-16 through the DCF. Discards for GSA 17 were present just for 2011, 2013 and 2014 for the Italian fleet. They were negligible or considered unreliable thus they were not included in the stock assessment. For more details on discards please see sections 5.2.10-5.2.11 in this report.

5.2.12.1.6 Fishing effort

Fishing effort data were reported to STECF EWG 15-16 through DCF. For more details on fishing effort, see sections 5.2.10-5.2.11 in this report.

Scientific surveys

5.2.12.1.7 Survey #1 (MEDITS)

5.2.12.1.7.1 Methods

Based on the DCF data call, abundance and biomass indices were re-calculated. MEDITS data from Croatia in GSA 17 were provided by the experts since in the database they were present just for 2013 and 2014. The data coming from MEDITS surveys are presented in sections 5.2.10-5.2.11 of this report.

5.2.12.1.7.2 Geographical distribution

Information on the spatial and temporal distribution of Deep water rose shrimp recruits as well as of adults in GSAs 18, and 19 is presented in sections 5.2.10-5.2.11 of this report.

5.2.12.1.7.3 Trends in abundance and biomass

Deep water rose shrimp time series of abundance and biomass indices from MEDITS surveys are shown and described in sections 5.2.10-5.2.11 of this report.

5.2.12.1.7.4 Trends in abundance by length or age

The stratified abundance indices of deep-water rose shrimp are shown and described in sections 5.2.10-5.2.11 of this report.

Stock Assessment

5.2.12.1.8 Method: XSA

FLR libraries were employed in order to carry out an XSA based assessment. The Deep water rose shrimp stock in GSAs 17-19 was assessed for the first time. XSA was carried out using as input data the period 2007-2014 for the catch data and 2007-2014 for the tuning file.

5.2.12.1.9 Input data

The growth parameters used for VBGF were L_{inf}= 45 mm CL; K = 0.6 yr^{-1}; t_0= -0.2 yr. The length-to-weight coefficients used were a= 0.0043, b= 2.376.
Total catches and catch numbers at age from the single GSAs were used as input data. SOP correction was applied to GSA 17 catch numbers at age. The R script prepared by JRC was used to create a combined stock object to be used in the assessment. Natural mortality and maturity were estimated as weighed mean by the catch numbers from the parameters used in the assessments of the single GSAs.
Table 5.2.12.7.2.1 lists the input parameters to the XSA, namely landings, catch number at age, weight at age, maturity at age, natural mortality at age and the tuning series at age.

Table 5.2.12.7.2.1. Deep-water rose shrimp in GSAs 17-19. Input data to the XSA model.

Catches (t)

2007	2008	2009	2010	2011	2012	2013	2014

2080	2175	2283	2336	2078	1598	1859	1960

Catch numbers-at-age matrix (thousands)

Age	2007	2008	2009	2010	2011	2012	2013	2014
0	175423	195970	188939	178187	127402	127526	182735	159140
1	108391	110353	111951	138764	111479	69789	107305	95365
2	5490	4370	5609	6870	6687	3038	4340	5459
3+	342	139	456	259	324	159	216	225

Weights-at-age in the catch and in the stock (kg)

Age	2007	2008	2009	2010	2011	2012	2013	2014
0	0.005	0.005	0.006	0.005	0.006	0.006	0.004	0.005
1	0.010	0.010	0.010	0.010	0.011	0.011	0.011	0.011
2	0.020	0.020	0.020	0.018	0.020	0.020	0.020	0.020
3+	0.027	0.027	0.028	0.024	0.028	0.025	0.027	0.027

Maturity and natural mortality vectors.

Age	0	1	2	3+
Maturity	0.2331	0.9998	1.0000	1.0000
M	1.41	0.81	0.70	0.65

MEDITS number (n/km^2) at age for GSA 17.

Age	2007	2008	2009	2010	2011	2012	2013	2014
0	127.3	209.9	83.6	46.1	49.2	170.0	81.2	266.7
1	521.2	275.3	127.0	198.8	96.3	153.1	133.0	200.2
2	114.7	28.6	38.0	14.3	5.9	15.6	10.4	7.9
3+	23.3	0.4	4.9	0.5	0.2	1.5	0.4	0.6

MEDITS number (n/km^2) at age for GSA 18.

Age	2007	2008	2009	2010	2011	2012	2013	2014
0	141.4	209.1	715.1	476.5	464.4	456.2	241.2	702.8
1	233.0	538.2	336.0	303.5	231.9	322.5	87.8	237.7
2	66.7	177.2	25.3	24.8	16.7	9.0	11.0	10.1
3+	16.3	38.9	2.0	4.3	0.6	0.1	0.4	1.1

MEDITS number (n/km^2) at age for GSA 19.

Age	2007	2008	2009	2010	2011	2012	2013	2014
0	485.5	765.7	1002.0	906.4	566.3	661.3	1092.5	758.2
1	116.3	284.4	431.1	463.8	254.0	353.3	247.7	208.4
2	7.8	8.8	27.9	22.2	11.2	13.1	31.9	8.4
3+	0.5	0.7	0.5	0.6	0.3	0.5	1.7	0.8

5.2.12.1.10 Results

Sensitivity analyses were conducted to assess the effect of the main parameters. Values ranging from 0.5 to 3 (0.5 increasing) for the shrinkage, values ranging from 1 to 3 for shrinkage years and a combination of values between 1 to 3 for the qage parameter and from -1 to 1 for the rage parameter have been tested. Comparison of trends between the settings has been done. Different combinations between the settings that looked more stable were tested.

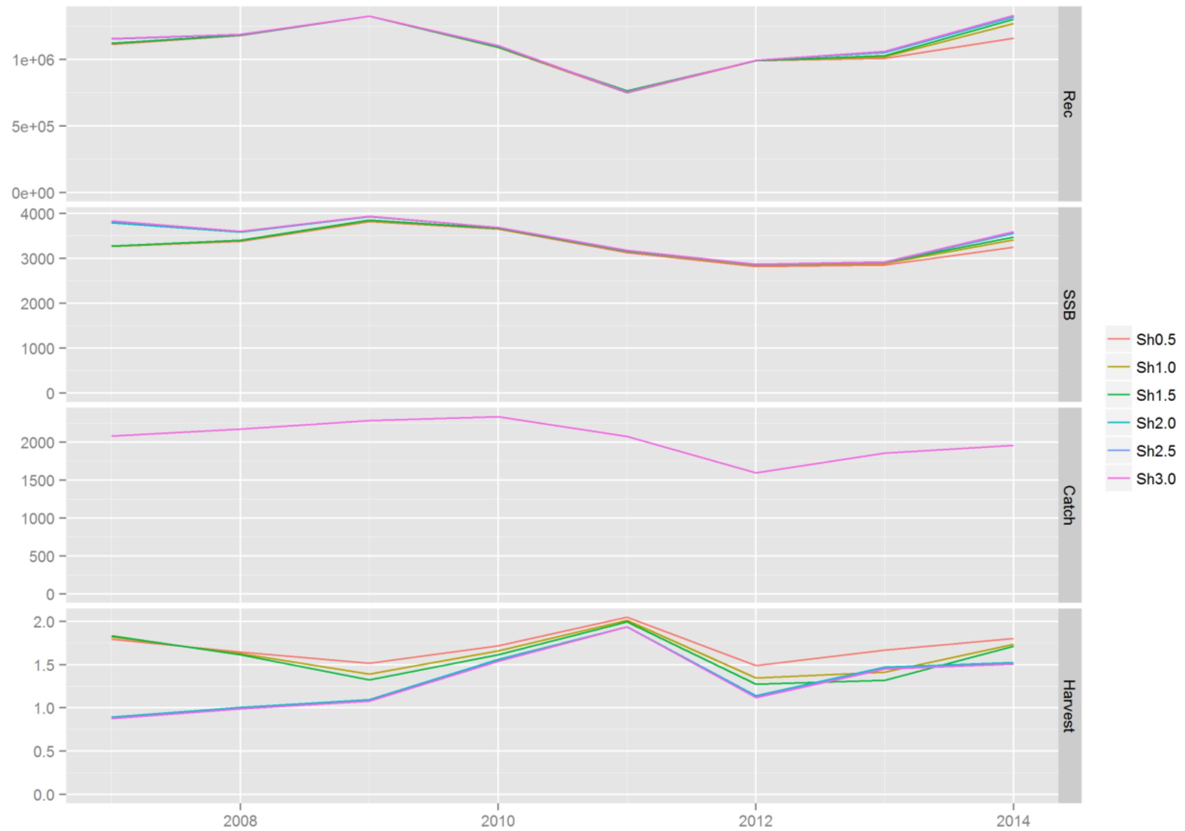


Figure 5.2.12.7.3.1. Deep-water rose shrimp in GSA 17-19. Sensitivity on shrinkage weight.

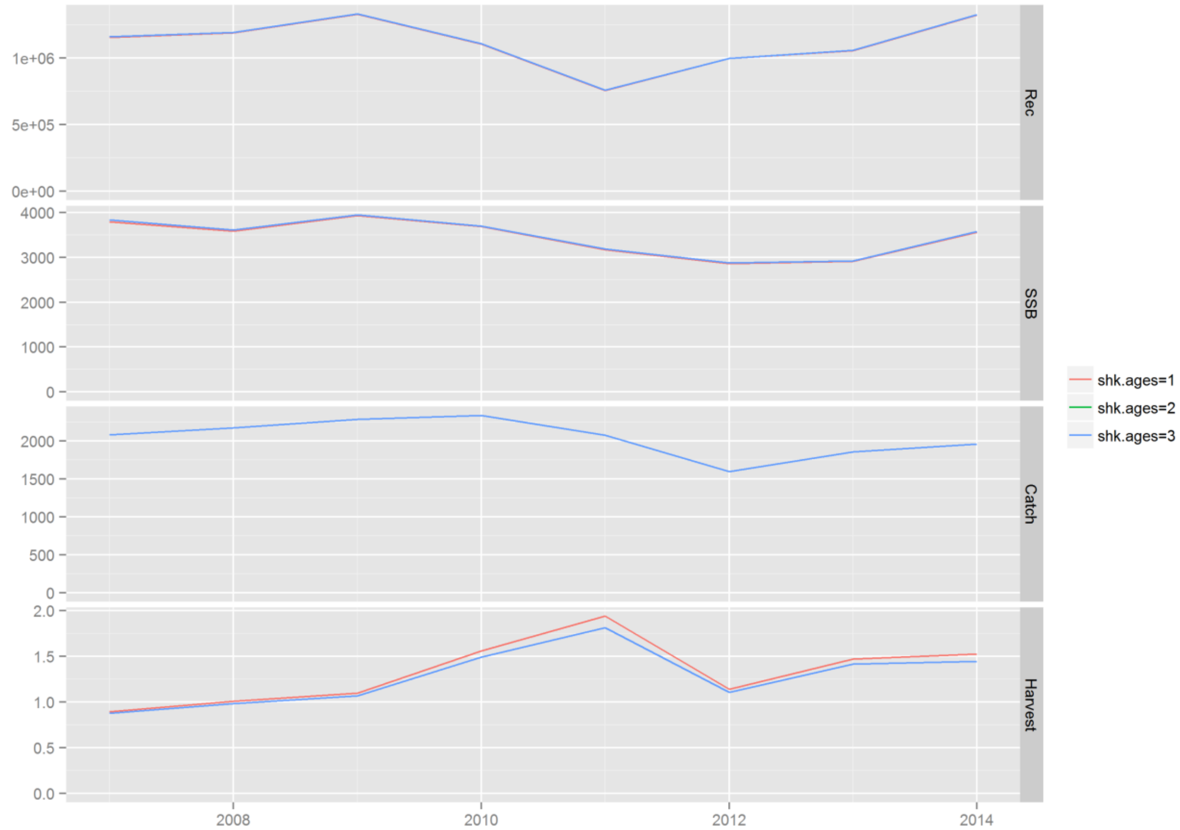


Figure 5.2.12.7.3.2. Deep-water rose shrimp in GSA 17-19. Sensitivity on shrinkage age.

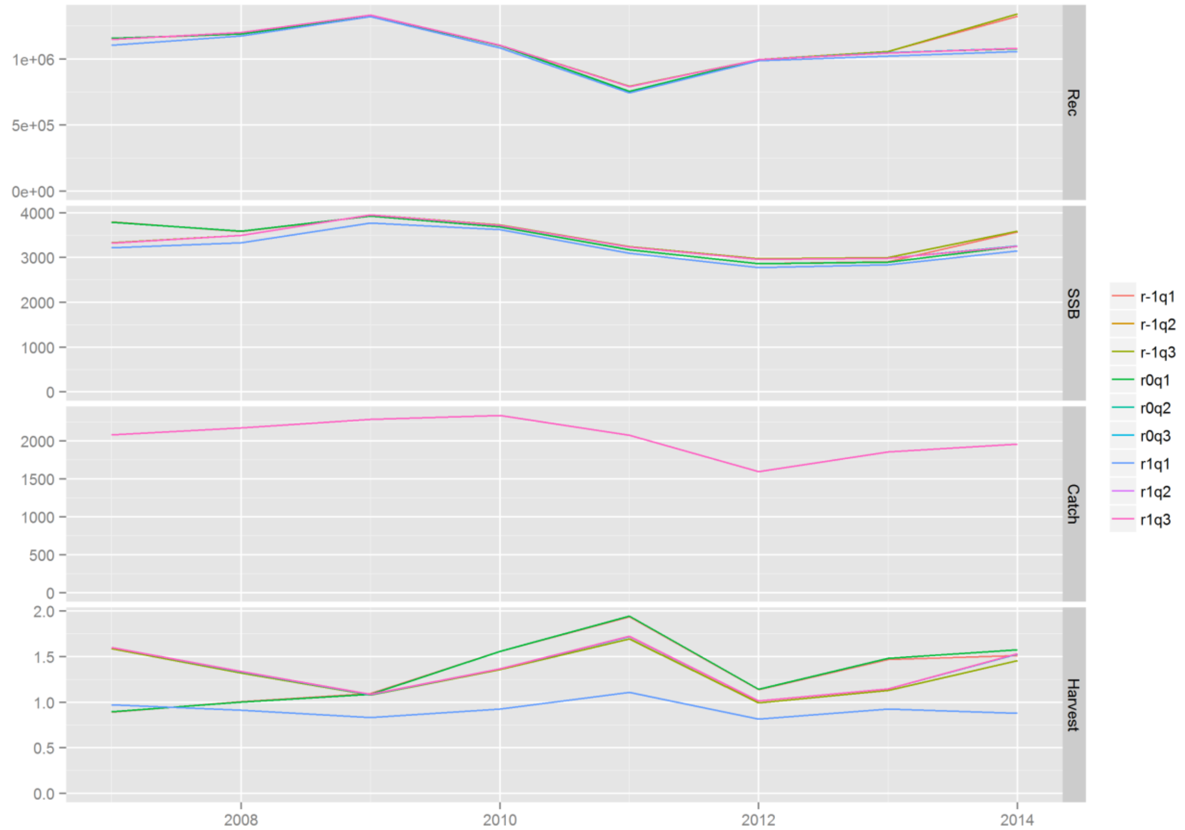


Figure 5.2.12.7.3.3. Deep-water rose shrimp in GSA 17-19. Sensitivity on qage and rage.

In Table 5.2.12.7.3.1 the residuals of the models with different shrinkage values are presented.

Table 5.2.12.7.3.1. Deep-water rose shrimp in GSA 17-19. Minimum, maximum, and average residual values of the XSA models with different shrinkage weight values for the three tuning fleets.

	MEDITS GSA 17			MEDITS GSA 18			MEDITS GSA 18		
Shrinkage	**Min**	**Max**	**Avg**	**Min**	**Max**	**Avg**	**Min**	**Max**	**Avg**
Sh0.5	-0.859	2.639	0.586	-1.142	2.786	0.525	-0.810	0.991	0.293
Sh1.0	-0.842	2.733	0.560	-1.103	2.826	0.532	-0.771	0.468	0.244
Sh1.5	-0.835	2.786	0.560	-1.074	2.849	0.538	-0.746	0.464	0.217
Sh2.0	-0.837	0.897	0.306	-1.034	1.427	0.459	-2.762	0.731	0.466
Sh2.5	-0.836	0.893	0.298	-1.034	1.399	0.463	-2.796	0.705	0.470
Sh3.0	-0.835	0.890	0.296	-1.034	1.385	0.466	-2.815	0.690	0.473

As a result, the settings that minimized the residuals and showed the best diagnostics output were used for the final assessment, and are the following:

Fbar	**fse**	**rage**	**qage**	**shk.yrs**	**shk.age**
0-2	2	-1	1	3	1

The residuals pattern of the MEDITS trawl survey is shown in Figure 5.2.12.7.3.4.

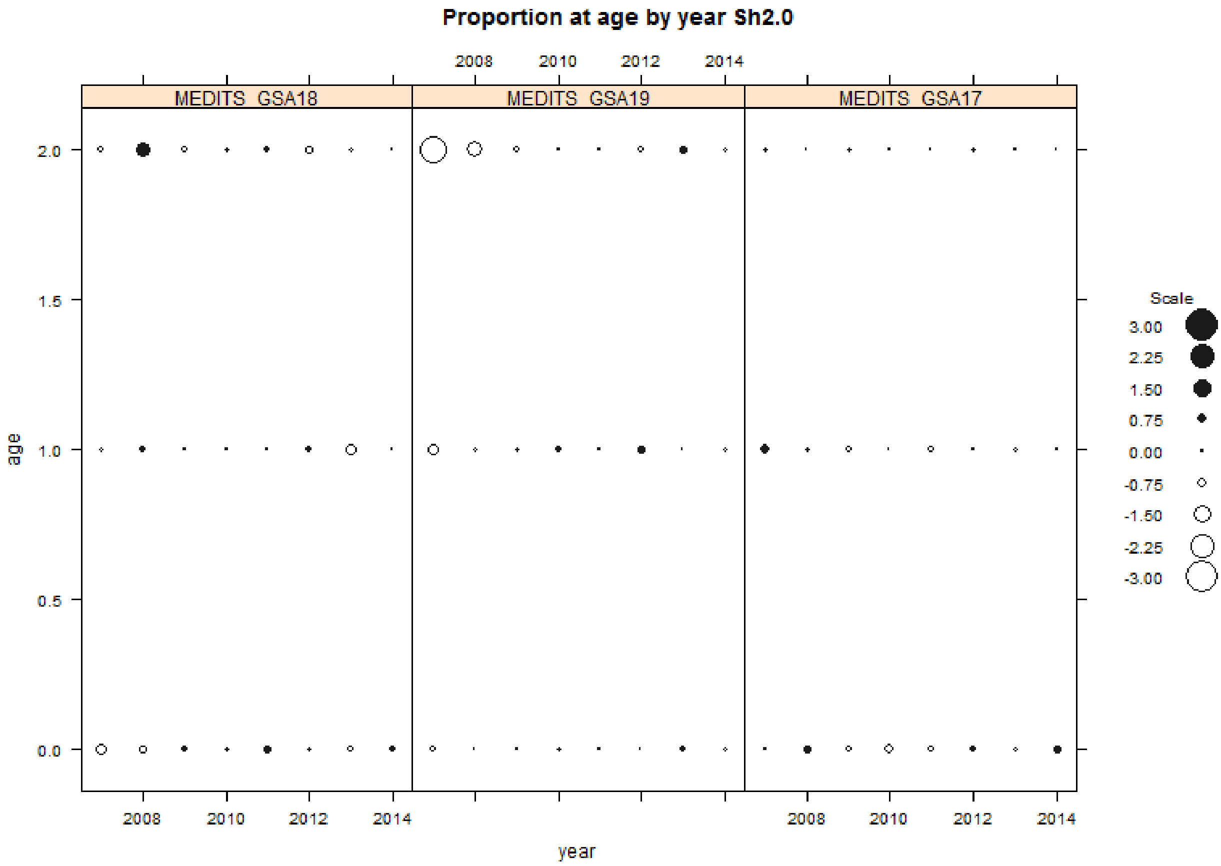


Figure 5.2.12.7.3.4. Deep-water rose shrimp in GSA 17-19. XSA residuals for the MEDITS survey from 2007 to 2014.

The results of the retrospective analysis are shown in Figure 5.2.12.7.3.5.

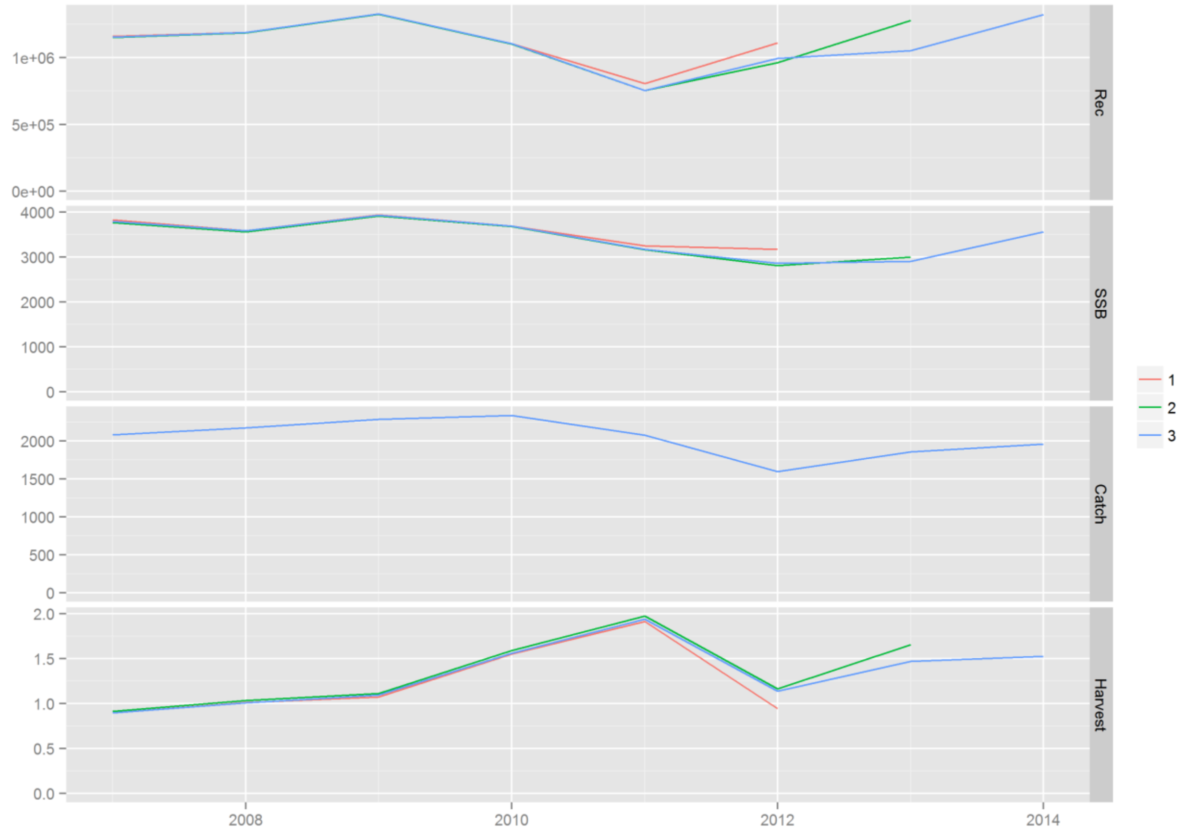


Figure 5.2.12.7.3.5. Deep-water rose shrimp in GSA 17-19. XSA retrospective analysis.

The results of the XSA are shown in the following figure.

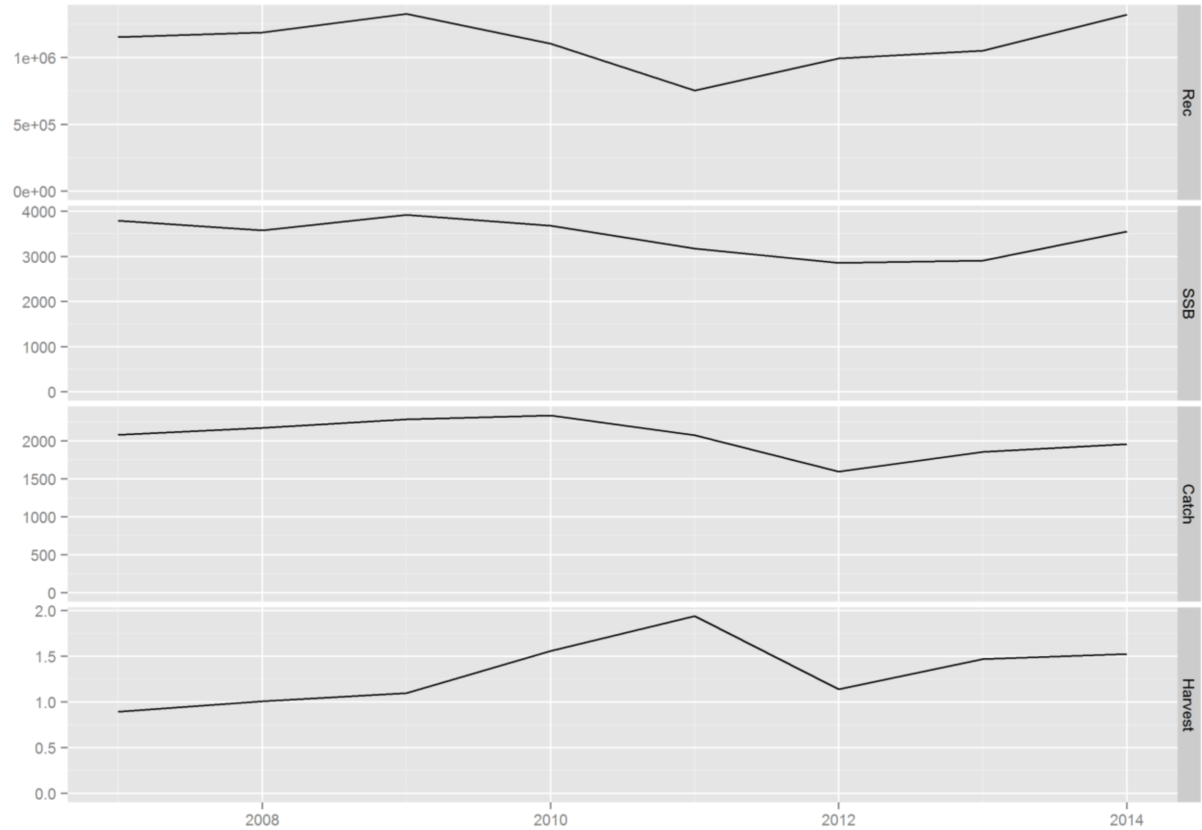


Figure 5.2.12.7.3.6. Deep-water rose shrimp in GSA 17-19. XSA summary results. SSB and catch are in tonnes, recruitment in 1000s individuals.

In the tables 5.2.12.7.3.2 and 3 the population estimates of deep water rose shrimp obtained by XSA are provided.

Table 5.2.12.7.3.2. Deep-water rose shrimp in GSA 17-19. Stock numbers at age (in thousands) as estimated by XSA.

Age	2007	2008	2009	2010	2011	2012	2013	2014
0	1154184	1188554	1327266	1103608	755128	995808	1054080	1321770
1	189305	195109	193347	230687	181395	121409	180108	167056
2	25622	11919	13192	11343	10071	6341	7462	8553
3+	1531	355	998	378	416	305	331	307

Table 5.2.12.7.3.3. Deep-water rose shrimp in GSA 17-19. XSA summary results.

	Fbar0-2	Recruitment (thousands)	SSB (t)	TB (t)
2007	0.90	1154184	3792	8218
2008	1.01	1188554	3584	8142
2009	1.10	1327266	3926	9525
2010	1.56	1103608	3685	7917

2011	1.94	755128	3173	6648
2012	1.14	995808	2863	7445
2013	1.47	1054080	2909	5739
2014	1.53	1321770	3557	8626

	F at age			
	0	**1**	**2**	**3+**
2007	0.37	1.96	0.36	0.36
2008	0.41	1.88	0.73	0.73
2009	0.34	2.03	0.92	0.92
2010	0.40	2.32	1.96	1.96
2011	0.42	2.54	2.85	2.85
2012	0.30	1.98	1.14	1.14
2013	0.43	2.24	1.75	1.75
2014	0.28	1.94	2.36	2.36

The XSA results summarized in Table 5.2.12.7.3.3 and in Figure 5.2.12.7.3.6 show an increasing trend in the catches, recruitment, SSB and an estimated F_{curr} of 1.53.

Reference points

5.2.12.1.11 Methods

The FLBRP package allowed a Yield per recruit analysis and an estimate of some F-based Reference Points as F_{max} and $F_{0.1}$. Yield per Recruit computation was made using R project software and the FLR libraries. The fishing mortality rate corresponding to $F_{0.1}$ in the yield per recruit curve is considered here as a proxy of F_{MSY}.

5.2.12.1.12 Input data

The input parameters were the same used for the XSA stock assessment and its results.

5.2.12.1.13 Results

Table 5.2.12.8.3.1. Deep-water rose shrimp in GSA 17-19. Reference points were estimated using the Yield per recruit analysis.

refpt	harvest	yield	rec	ssb	biomass
f0.1	0.69	0.00	1.00	0.00	0.01

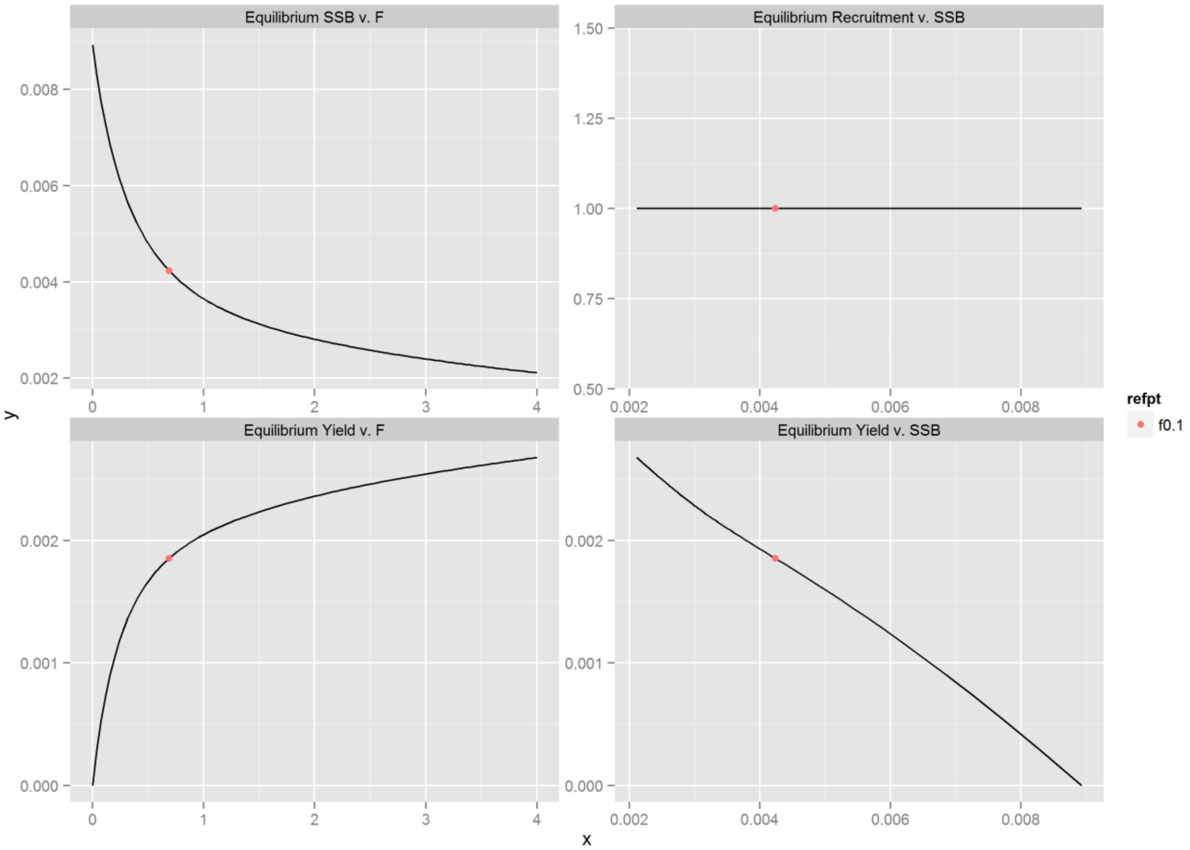


Figure 5.2.12.8.3.1. Deep-water rose shrimp in GSA 17-19. Yield per recruit curve.

Data quality

Data from DCF 2014 as submitted through the Official data call in 2015 were used. Discards for GSA 17 were present just for 2011, 2013 and 2014 for the Italian fleet. Some of the discard data were considered unreliable since the length of the discarded animals were above the minimum landing size. Landings data for GSA 17 were incomplete. Italian landings were present just for 2002, 2003, 2006, 2011, 2013 and 2014. Croatian landings were present just for 2014 in the DCF database because previously there was no obligation to monitor that species. MEDITS data from Croatia in GSA 17 in the database were present just for 2013 and 2014.

Short term predictions 2015-2017

5.2.12.1.14 Method

A deterministic short term prediction for the period 2015 to 2017 was performed using the FLR routines provided by JRC and based on the results of the XSA stock assessments performed during EWG 15-16.

5.2.12.1.15 Input parameters

The input parameters were the same used for the XSA stock assessment and its results. An average of the last three years has been used for weight at age, maturity at age and F at age.

Recruitment (age 0) has been estimated from the population results as the geometric mean of the last 3 years (1115325 thousand individuals).

5.2.12.1.16 Results

Table 5.2.12.10.3.1. Deep-water rose shrimp in GSA 17-19. Short term forecast in different F scenarios. Basis: F(2015) = mean (F_{bar} 0-2 2012-2014)= 1.37; R(2015) = geometric mean of the recruitment of the last 3 years; R = 1115325 thousands; SSB(2014) = 3557 t, Catch (2014)= 1960 t.

Rationale	Ffactor	Fbar	Catch 2015	Catch 2016	Catch 2017	SSB 2016	SSB 2017	Change SSB 2016-2017(%)	Change Catch 2014-2016(%)
Zero catch	0.00	0.00	2780	0	0	3678	6140	66.96	-100.00
High long term yield (F0.1)	0.51	0.69	2780	1588	1941	3678	4451	21.03	-18.98
Status quo	1.00	1.37	2780	2477	2446	3678	3630	-1.30	26.37
Different Scenarios	0.10	0.13	2780	401	644	3678	5692	54.78	-79.52
	0.20	0.26	2780	752	1117	3678	5311	44.42	-61.63
	0.30	0.39	2780	1060	1468	3678	4985	35.56	-45.90
	0.40	0.53	2780	1333	1731	3678	4705	27.94	-31.99
	0.50	0.66	2780	1576	1931	3678	4463	21.36	-19.61
	0.60	0.79	2780	1793	2086	3678	4252	15.62	-8.52
	0.70	0.92	2780	1989	2206	3678	4067	10.60	1.47
	0.80	1.05	2780	2166	2303	3678	3904	6.17	10.53
	0.90	1.18	2780	2328	2381	3678	3759	2.23	18.79
	1.10	1.44	2780	2614	2501	3678	3513	-4.47	33.36
	1.20	1.58	2780	2741	2548	3678	3407	-7.35	39.84
	1.30	1.71	2780	2859	2590	3678	3310	-9.98	45.88
	1.40	1.84	2780	2970	2627	3678	3222	-12.40	51.53
	1.50	1.97	2780	3074	2661	3678	3140	-14.63	56.85
	1.60	2.10	2780	3173	2692	3678	3063	-16.70	61.87
	1.70	2.23	2780	3266	2721	3678	2992	-18.63	66.62
	1.80	2.36	2780	3354	2748	3678	2926	-20.45	71.13
	1.90	2.50	2780	3438	2773	3678	2863	-22.15	75.43
	2.00	2.63	2780	3519	2798	3678	2804	-23.76	79.54

Short term predictions 2015-2017 by fleet

5.2.12.1.17 Method

A deterministic short term prediction by fleet for the period 2015 to 2017 was performed using the FLR routines provided by JRC and based on the results of the XSA stock assessments performed during EWG 15-16.

5.2.12.1.18 Input parameters

The same parameters used in the short term by single fleet were used.

5.2.12.1.19 Results

Table 5.2.12.11.3.1. Deep-water rose shrimp in GSA 17-19. Short term forecast by fleet and GSA.

Fleet	Year	Catches	Scenario	Partial_F
alb18	2015	456	$F_{0.1}$	0.14
alb18	2016	248	$F_{0.1}$	0.07
alb18	2017	280	$F_{0.1}$	0.07
hvr17	2015	282	$F_{0.1}$	0.23
hvr17	2016	167	$F_{0.1}$	0.12
hvr17	2017	233	$F_{0.1}$	0.12
ita17	2015	125	$F_{0.1}$	0.11
ita17	2016	73	$F_{0.1}$	0.05
ita17	2017	101	$F_{0.1}$	0.05
ita18	2015	1133	$F_{0.1}$	0.59
ita18	2016	638	$F_{0.1}$	0.30
ita18	2017	797	$F_{0.1}$	0.30
ita19	2015	816	$F_{0.1}$	0.27
ita19	2016	448	$F_{0.1}$	0.14
ita19	2017	509	$F_{0.1}$	0.14
mon18	2015	46	$F_{0.1}$	0.03
mon18	2016	26	$F_{0.1}$	0.01
mon18	2017	33	$F_{0.1}$	0.01
alb18	2015	456	F_{sq}	0.14
alb18	2016	392	F_{sq}	0.14
alb18	2017	392	F_{sq}	0.14
hvr17	2015	282	F_{sq}	0.23
hvr17	2016	250	F_{sq}	0.23
hvr17	2017	243	F_{sq}	0.23
ita17	2015	125	F_{sq}	0.11
ita17	2016	109	F_{sq}	0.11
ita17	2017	105	F_{sq}	0.11
ita18	2015	1133	F_{sq}	0.59
ita18	2016	975	F_{sq}	0.59
ita18	2017	959	F_{sq}	0.59
ita19	2015	816	F_{sq}	0.27
ita19	2016	737	F_{sq}	0.27
ita19	2017	732	F_{sq}	0.27
mon18	2015	46	F_{sq}	0.03
mon18	2016	39	F_{sq}	0.03
mon18	2017	38	F_{sq}	0.03

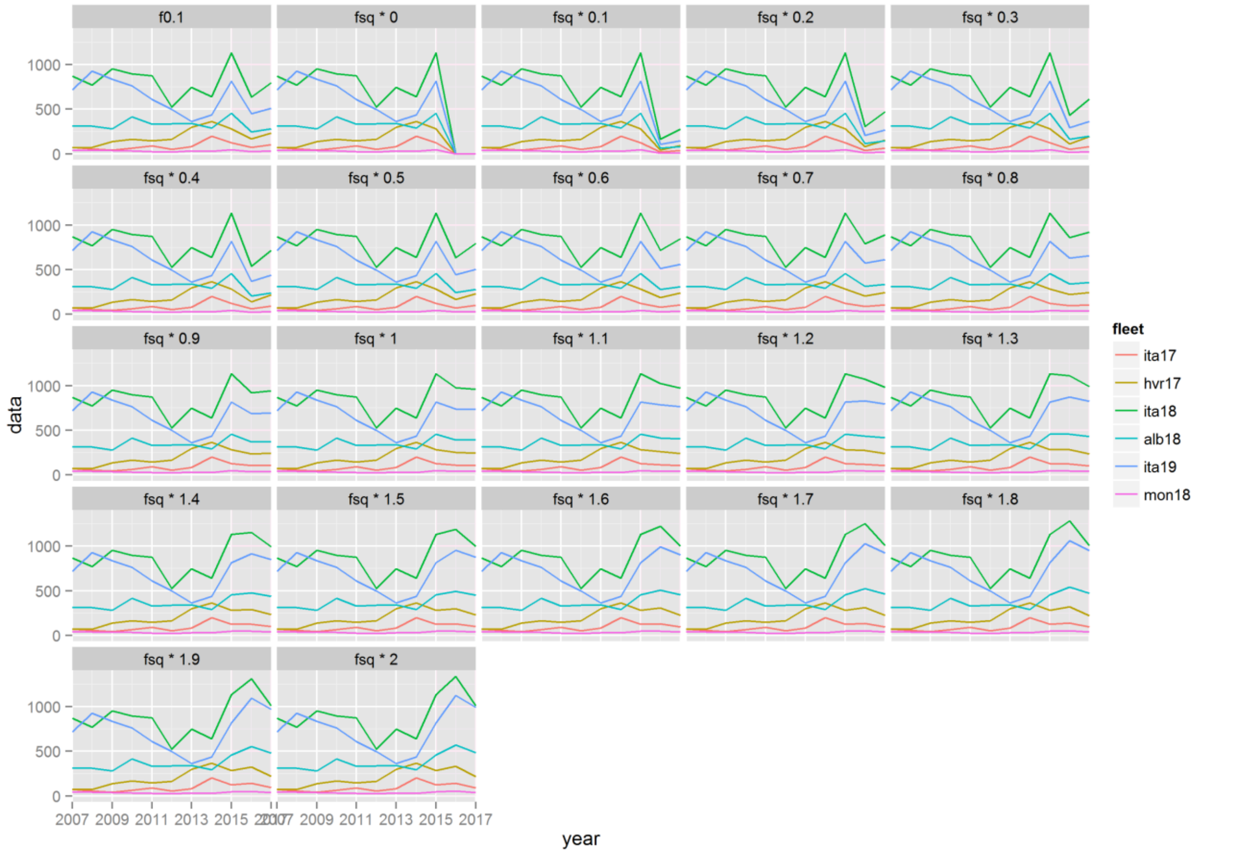


Figure 5.2.12.11.3.1. Deep-water rose shrimp in GSA 17-19. Short term forecast by fleet and GSA.

Medium term predictions

5.2.12.1.20 Method

Medium term forecasts were not conducted because no meaningful stock-recruitment relationship was estimated.

Stock advice

The current F (1.53) is larger than $F_{0.1}$ (0.69), chosen as proxy of F_{MSY} and as the exploitation reference point consistent with high long term yields, which indicates that Deep water rose shrimp in GSA 17-19 is being fished above F_{MSY}. Catches of deep-water rose shrimp in 2016 consistent with F_{MSY} should not exceed 1588 tonnes.

Management strategy evaluation

A Management Strategy Evaluation was run to evaluate if the MSY ranges were precautionary. The F_{MSY} ranges were derived using the formula provided by STECF EWG 15-09. F ranges results were F_{upper}=0.94 and F_{lower}=0.46. B_{lim} was estimated as B_{loss}=2863 (t). The following figure shows the results of the MSE.

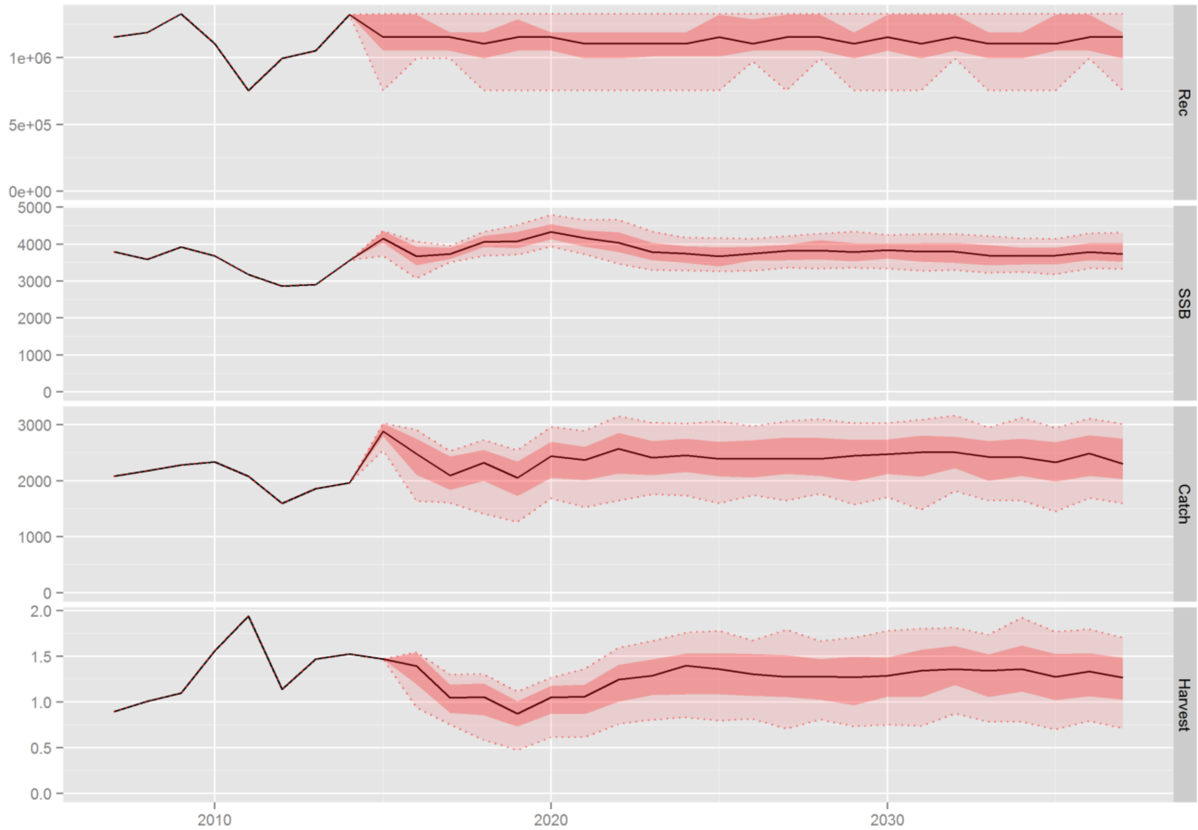


Figure 5.2.12.14.1. Deep-water rose shrimp in GSA 17-19. Management Strategy Evaluation.

The probability of SSB to fall below B_{lim} at F = F_{upper} is equal to 0.

5.2.13 STOCK ASSESSMENT OF GIANT RED SHRIMP IN GSA 18

5.2.13.1 Stock Identification

The stock of giant red shrimp (*Aristaeomorpha foliacea)* was assumed to be confined in the boundaries of the whole GSA 18, lacking specific information on stock identity. In the past this species was considered rare in this GSA, though recently has become more frequent in the experimental catches of the trawl surveys and in the commercial catches as well.

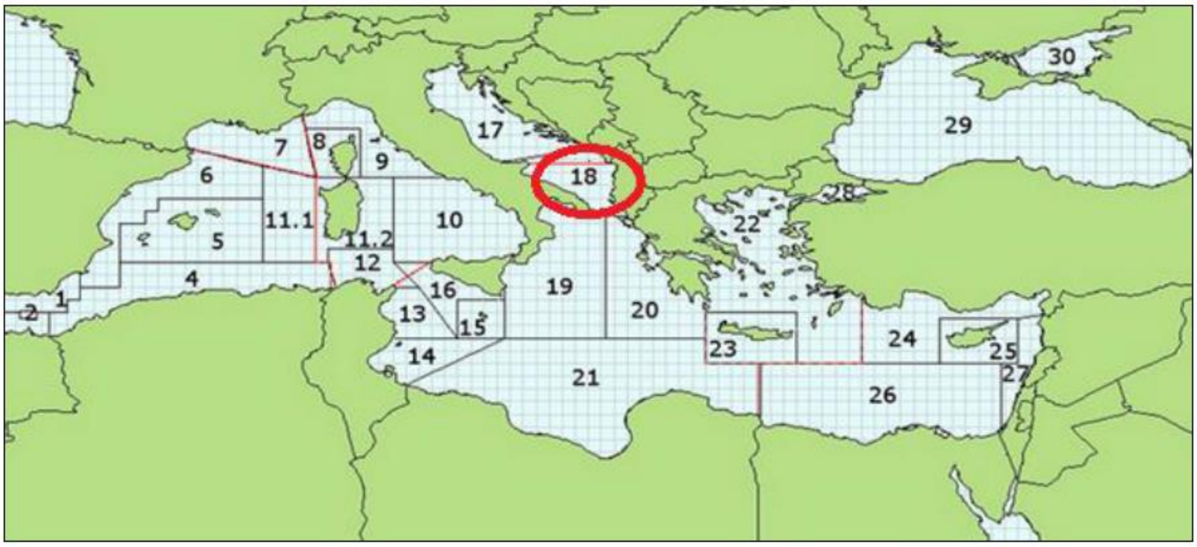


Figure 5.2.13.1.1 Geographical location of GSA 18.

5.2.13.2 Growth

The estimates of von Bertalanffy growth parameters for males and females used in the assessment are presented in Table 5.2.13.2.1 below.

Table 5.2.13.2.1. Giant red shrimp in GSA 18. Growth parameters submitted through the official DCF data call.

Year	Sex	vb_linf	vb_k	vb_t0	Sample Size	Size Range	Units	Method Used
2009	F	73	0.438	-0.1	564	11-59	mm	length frequency analysis
2010	F	73	0.438	-0.1	564	11-59	mm	length frequency analysis
2011	F	73	0.438	-0.1	564	11-59	mm	length frequency analysis
2012	F	73	0.438	-0.1	564	11-59	mm	length frequency analysis
2013	F	73	0.438	-0.1	564	11-59	mm	length frequency analysis
2014	F	73	0.438	-0.1	564	11-59	mm	length frequency analysis
2009	M	46	0.5	-0.1	437	14-42	mm	length frequency analysis
2010	M	46	0.5	-0.1	437	14-42	mm	length frequency analysis
2011	M	52	0.35	-0.1	437	14-50	mm	length frequency analysis
2012	M	52	0.35	-0.1	437	14-50	mm	length frequency analysis
2013	M	52	0.35	-0.1	437	14-50	mm	length frequency analysis
2014	M	52	0.35	-0.1	437	14-50	mm	length frequency analysis

5.2.13.3 Maturity

Juveniles recruiting in spring are immature, with only a few individuals reproducing during their first year. Gonadic development begins in winter and individuals reach sexual maturity during the summer of their second year (Bianchini, 1999; Politou et al., 2004). Once they have reached maturity male giant red shrimp have a protracted reproductive capacity and are ready to mate throughout the year, whilst females mature seasonally (Bianchini 1999; Perdichizzi et al., 2012).

The reproduction period of giant red shrimp lasts from May to September, with a peak in the summer (July-August). Four stages of ovary maturity were described by using a macroscopic colorimetric scale (Levi and Vacchi, 1989) and the mature ovaries can be recognised because initially they are grey coloured, with increasingly dark shades until they become black, due to the presence of carotenoproteins (Orsi Relini and Semeria, 1983).

Mature females are concentrated in the mesobathyal bottoms from spring to autumn; in GSA 18, mature females have been found to occur in particular during summer in deeper waters down to 500 m depth (MEDISEH, 2013). The fertility of giant red shrimp has been estimated as being equal approximately to 1/3 of the fertility of *A. antennatus* (Orsi Relini and Semeria, 1983). Analyses of the ultrastructure of the ovary indicated cells arranged in a line. Giant red shrimp has a dome-shaped thelycum and characteristics which can be compared to those of decapod crustaceans with a closed thelycum, with coupling coinciding with the moult phases (Orsi Relini L., in Anonymous, 1997). In males the spermatophore originates by passing through the deferent duct, and the spermatic mass is contained in a chamber with “wings” at the edge that serve a protective purpose.

Female maturity data was obtained from commercial data gathered through the DCF. Individuals belonging to the maturity stage 2b (according to the MEDITS maturity scale) onwards were grouped as mature. The proportion of mature individuals by length were age sliced to obtain the proportion of mature individuals by age.

Table 5.2.13.3.1. Giant red shrimp in GSA 18. Proportion of mature females by age.

Sex	Age Class	Prop. Mature
F	0	0
F	1	0.59
F	2	1
F	3	1
F	4+	1

The sex ratio vector (observed ratio F/(F+M)) was estimated based on DCF commercial catch data for the years 2009 and 2012 (Figure 5.2.13.3.1). Females were dominant in the smaller sizes, whilst between 28 and 38 mm CL males became dominant. From 39 mm CL onwards females were once again dominant.

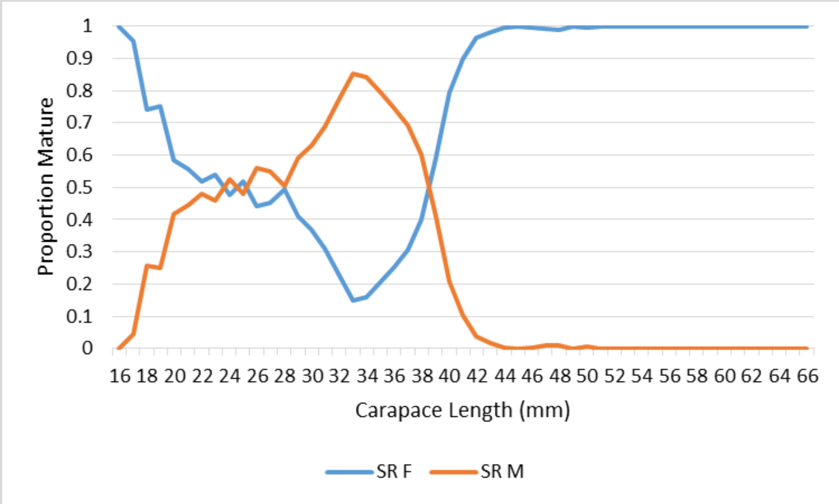


Figure 5.2.13.3.1. Giant red shrimp in GSA 18. Sex ratio by length in GSA 18.

5.2.13.4 Natural mortality

A vector of natural mortality was estimated using PRODBIOM (Abella et al., 1997), and is shown in Table 5.2.13.4.1.

Table 5.2.13.4.1. Giant red shrimp in GSA 18. Natural mortality vector.

Age	M
0	1.17
1	0.61
2	0.43
3	0.36
4+	0.28

5.2.13.5 Fisheries

5.2.13.5.1 General description of the fisheries

The Giant red shrimp is only targeted by trawlers on fishing grounds located offshore at 200 m depth, mainly in the northernmost and southernmost parts of GSA 18 between 400 and 700 m depth. Giant red shrimp occurs together with blue and red shrimp (*Aristeus antennaus*), deepwater rose shrimp (*Parapenaeus longirostris*) and Norway lobster (*N. norvegicus*), depending on operative depth and area.

5.2.13.5.2 Management regulations applicable in 2015

At present there are no formal management objectives for giant red shrimp fisheries in GSA 18. As in other areas of the Mediterranean, stock management is based on control of fishing capacity (licenses), fishing effort (fishing activity), technical measures (mesh size and area/season closures). In order to limit the over-capacity of the fishing fleet, Italian fishing licenses have been fixed since the late eighties and the fishing capacity has been gradually reduced.

To protect coastal habitats the use of towed gears is prohibited within 3 nm of the coast or within the 50 m isobath if the latter is reached closer to the coast (EC 1967/2006; Res. GFCM 36/2012/3). In order to protect deep water habitats trawling at depths beyond 1000 m is also prohibited at EU and GFCM level (EC 1967/2006; Rec. GFCM 2005/1).

In terms of technical measures, EC 1967/2006 fixed a minimum mesh size of 40 mm for bottom trawling of EU fishing vessels. Mesh size had to be modified to square 40 mm square or at the duly justified request of the ship owner a 50 mm diamond mesh in July 2008; derogations were only possible up to 2010. Moreover diamond mesh panels can only be used if it is demonstrated that size selectivity is of equivalent or higher than using 40 mm square mesh panels (EC 1343/2011).

In 2008 a management plan was adopted, that foresaw the reduction of fleet capacity associated with a reduction of the time at sea. Two biological conservation zone (ZTB) were permanently established in 2009 (Decree of Ministry of Agriculture, Food and Forestry Policy of 22.01.2009; GU n. 37 of 14.02.2009) along the mainland, offshore Bari (180 km^2, between about 100 and 180 m depth), and in the vicinity of Tremiti Islands (115 km^2 along the bathymetry of 100 m) on the northern border of the GSA, where a marine protected area (MPA) had been established in 1989. In the former only the professional small scale fishery using fixed nets and long-lines is allowed, from January 1st to June 30th, while in the latter the trawling fishery is allowed from November 1st to March 31st and the small scale fishery all year round.

There is no minimum landings size for *A. foliacea* in European legislation.

5.2.13.5.3 Landings

No landings of giant red shrimp are reported from Montenegro or Albania in the FAO FishStat database.

Official EU DCF landings data for giant red shrimp in GSA 18 was available for the period 2003-2014. Landings peaked in 2003 and 2006, at 198 and 169 tonnes respectively. However data for 2003 may be partly erroneous since 12.7 tonnes of giant red shrimp caught by set gillnets (GNS) were reported. Landings decreased steadily between 2010 and 2014. The lowest landings of the entire time series (8.1 tonnes) were reported in 2014 (Figure 5.2.13.5.3.1).

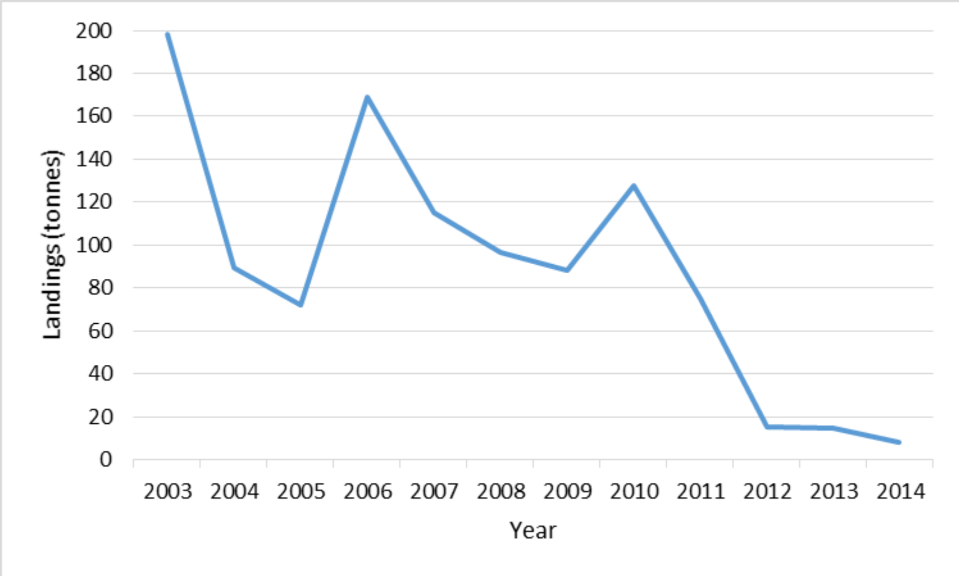


Figure 5.2.13.5.3.1. Giant red shrimp in GSA 18. Total landings (tonnes) 2003-2014.

Table 5.2.13.5.3.1. Giant red shrimp in GSA 18. Landings (tonnes) by gear and fishery in 2003-2014 as reported through the EU DCR / DCF. Gear codes: GNS – set gillnets; OTB – bottom otter trawl.

Year	Gear	Fishery	Mesh Size Range (mm)	Landings (tonnes)
2003	-1	-1	-1	72.3
2003	GNS	-1	-1	12.7
2003	OTB	-1	-1	113.0
2004	OTB	MDDWSP	40D50	89.1
2005	OTB	MDDWSP	40D50	72.1
2006	-1	-1	-1	3.1
2006	OTB	MDDWSP	40D50	165.6
2007	OTB	MDDWSP	40D50	114.9
2008	OTB	MDDWSP	40D50	37.1
2008	OTB	DWSP	40D50	59.6
2009	OTB	-1	-1	88.4
2010	OTB	-1	-1	127.4
2011	OTB	-1	-1	75.2
2012	OTB	MDDWSP	50D100	15.0
2013	OTB	MDDWSP	50D100	14.5
2014	OTB	MDDWSP	50D100	8.1

Table 5.2.13.5.3.2. Giant red shrimp in GSA 18. Length frequency distribution (thousands of individuals) of landings of bottom otter trawlers in 2009-2014 as reported through the EU DCR / DCF.

	Year					
CL (mm)	2009	2010	2011	2012	2013	2014
16	0.46	9.36	0.00	0.00	0.00	0.00
17	0.00	35.12	0.00	0.00	0.00	0.00
18	8.82	71.40	0.96	0.54	0.79	0.00

19	6.96	109.44	0.96	0.54	1.69	0.17
20	27.85	155.09	5.78	1.36	3.61	5.17
21	92.85	176.16	10.82	3.57	5.19	9.48
22	149.02	255.17	7.20	1.08	5.76	9.66
23	329.14	329.33	18.98	5.73	7.79	13.80
24	455.88	413.23	37.85	8.46	9.49	19.83
25	486.05	397.49	36.93	8.33	10.61	28.11
26	470.27	354.29	54.53	15.34	15.24	49.32
27	529.23	279.12	56.12	24.91	16.60	59.67
28	469.34	191.52	44.87	34.84	13.10	53.80
29	534.33	149.04	17.66	23.72	11.41	50.53
30	487.44	79.85	31.31	27.19	12.99	51.04
31	427.09	128.23	223.36	28.19	23.94	48.29
32	322.64	311.60	441.43	48.83	36.36	41.39
33	376.96	487.13	604.40	69.99	43.93	37.25
34	434.06	557.88	440.26	77.91	39.52	31.73
35	367.21	348.42	259.24	65.65	24.96	21.38
36	171.30	189.41	221.23	50.80	13.10	14.31
37	103.52	144.35	155.09	55.33	11.07	11.04
38	51.07	156.16	155.73	35.25	10.73	12.24
39	43.17	124.14	77.28	35.83	18.86	14.49
40	35.28	242.82	86.89	16.31	19.54	6.21
41	71.03	282.63	144.93	14.00	31.96	6.55
42	55.24	281.97	146.90	11.82	34.10	5.00
43	116.52	241.09	99.86	14.93	56.12	3.62
44	117.45	247.58	102.31	20.43	58.38	4.14
45	163.87	290.47	68.08	23.40	55.67	6.55
46	134.16	288.59	59.12	16.09	34.21	6.90
47	95.63	196.19	50.02	7.37	15.58	6.90
48	51.53	112.53	43.68	9.82	5.31	3.10
49	26.00	77.93	28.65	5.16	6.32	0.86
50	10.21	31.16	28.95	4.93	4.74	1.55
51	7.43	35.93	29.13	7.59	4.86	1.21
52	4.64	32.55	22.21	7.79	2.26	0.86
53	1.86	19.32	21.46	5.78	1.36	1.21
54	2.32	13.57	14.45	4.98	2.48	0.35
55	4.18	26.58	15.66	3.90	1.24	0.35
56	5.11	15.63	8.76	3.51	0.00	0.17
57	2.32	3.32	4.82	1.48	3.39	0.00
58	1.39	3.42	3.02	0.89	1.13	0.00
59	1.39	0.00	2.42	0.23	0.00	0.00
60	0.00	0.00	2.47	0.00	0.00	0.00
61	0.00	0.00	1.62	0.12	0.00	0.00
62	0.00	0.00	1.23	0.00	0.00	0.00

63	0.00	0.00	0.73	0.00	0.00	0.00
64	0.00	0.00	0.78	0.00	0.00	0.00
65	0.00	1.66	0.39	0.00	0.00	0.00
66	0.00	0.00	0.39	0.00	0.00	0.00

Table 5.2.13.5.3.3. Giant red shrimp in GSA 18. Catch at age (thousands of individuals) of bottom otter trawlers in 2009-2014 as reported through the EU DCR / DCF.

	Year					
Age (year)	2009	2010	2011	2012	2013	2014
0	1347.07	1492.01	129.37	37.35	41.57	102.21
1	3722.51	2889.60	766.81	203.23	238.93	307.36
2	2011.99	3189.45	1968.48	321.62	333.25	204.94
3	144.62	277.58	978.18	221.84	57.80	23.32
4	22.53	41.40	45.33	18.40	3.82	0.40
5	1.42	7.27	1.94	0.34	0.00	0.00
6	1.51	0.58	0.26	0.78	0.00	0.00
7	0.60	0.00	0.13	0.32	0.00	0.00
8	0.00	0.00	0.00	0.01	0.00	0.00
9	0.00	0.00	0.19	0.00	0.00	0.00
10	0.00	0.00	0.18	0.00	0.00	0.00
11	0.00	0.00	0.03	0.00	0.00	0.00

5.2.13.5.4 Discards

Discards data were available from the DCF for 2009 (0.19 tonnes) and 2011 (0.02 tonnes); the length frequency distribution of discards in these two years is shown in Figure 5.2.13.5.4.1. Overall the proportion of the discards of giant red shrimp in GSA 18 appears to be negligible.

No information on age structure of discards was available through the official EU DCF.

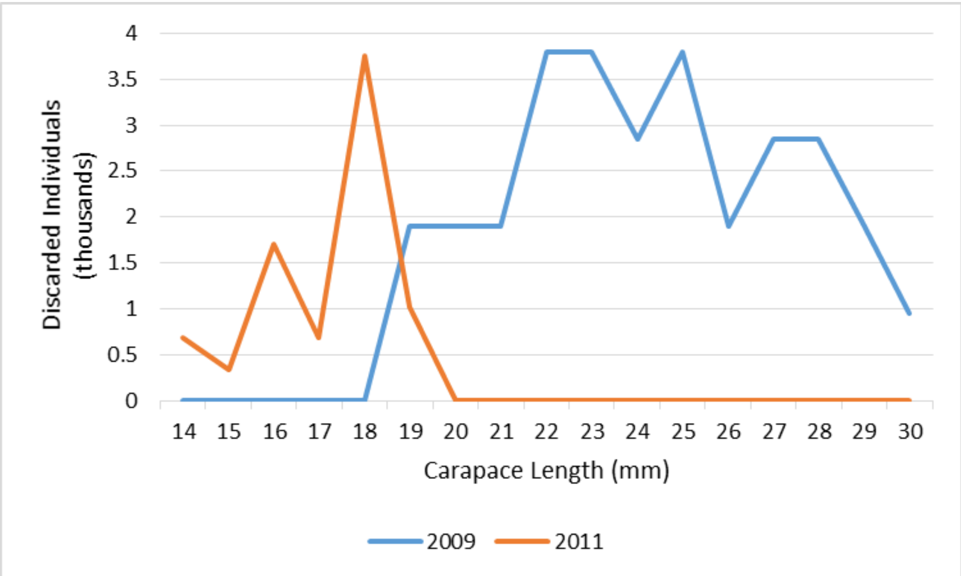


Figure 5.2.13.5.4.1. Giant red shrimp in GSA 18. Discard length frequency distributions in 2009 and 2011.

5.2.13.5.5 Fishing effort

Available DCF data show a steep decline in nominal fishing effort (engine kw*days) for bottom otter trawlers operating in GSA 18 (Figure 5.2.13.5.5.1 / Table 5.2.13.5.5.1).

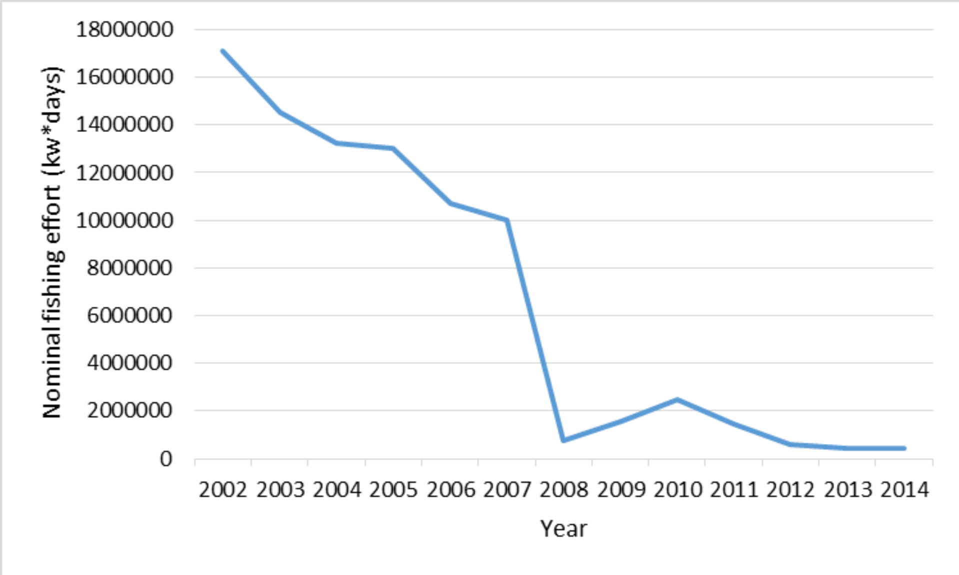


Figure 5.2.13.5.5.1. Giant red shrimp) in GSA 18. Trends in annual bottom otter trawler nominal fishing effort (kw*days) in GSA 18 from 2002 to 2014.

Table 5.2.13.5.5.1. Giant red shrimp in GSA 18. Annual nominal fishing effort (kW*days) in GSA 18 from 2002 to 2014 as reported through the DCF official data call. Fishery codes: -1 – no information; DWSP – deep water species; MDDWSP – mixed demersal and deep water species.

		Fishery			
Year	Gear	-1	DWSP	MDDWSP	Total
2002	OTB	17112022			17112022
2003	OTB	14530793			14530793
2004	OTB			13241221	13241221
2005	OTB			13024315	13024315
2006	OTB			10702114	10702114
2007	OTB			10017537	10017537
2008	OTB		130964	609325	740289
2009	OTB		108546	1478134	1586680
2010	OTB		124777	2344855	2469632
2011	OTB		46554	1399545	1446099
2012	OTB			596064	596064
2013	OTB			424108	424108
2014	OTB			449344	449344

Table 5.2.13.5.5.2. Giant red shrimp in GSA 18. Annual fishing effort (GT*days at sea) in GSA 18 from 2002 to 2014 as reported through the DCF official data call. Fishery codes: -1 – no information; DWSP – deep water species; MDDWSP – mixed demersal and deep water species.

		Fishery			
Year	Gear	-1	DWSP	MDDWSP	Total
2002	OTB	-1			-1
2003	OTB	-1			-1
2004	OTB			2356478	2356478
2005	OTB			2298474	2298474
2006	OTB			2058309	2058309
2007	OTB			1772419	1772419
2008	OTB		29701	119323	149024
2009	OTB		18235	266753	284988
2010	OTB		21524	437823	459347
2011	OTB		10809	281989	292798
2012	OTB			132377	132377
2013	OTB			94784	94784
2014	OTB			80351	80351

5.2.13.6 Scientific surveys

5.2.13.6.1 Survey #1 (MEDITS)

5.2.13.6.1.1 Methods

MEDITS surveys were carried out from late spring to mid-summer and the sampling design was random depth-stratified taking into account the following five depth strata: 10–50, 50–100, 100–200, 200–500 and 500–800 m. A GOC 73 trawl net was used during the surveys. The cod-end mesh size was of 20 mm in MEDITS surveys. The haul duration was 0.5 h for hauls carried out on the shelf (10–200m depth), and 1 h for hauls carried out on the slope (200–800 m depth) fishing grounds. Details of the MEDITS sampling protocol can be found in Bertrand *et al*. (2002) and the MEDITS standard protocol available online.

Based on the DCF data call, abundance and biomass indices were calculated. In GSA 18 the following number of hauls was reported per depth stratum (Table 5.2.13.6.1.1.1).

Table 5.2.13.6.1.1.1. Number of MEDITS hauls per year and depth stratum in GSA 18, in 1994 - 2014.

	Stratum					
Year	A	B	C	D	E	Total
1994	14	14	24	10	10	72
1995	15	14	23	10	10	72

1996	18	24	32	19	19	112
1997	17	25	33	18	19	112
1998	17	25	33	18	19	112
1999	17	26	32	19	18	112
2000	17	25	33	18	19	112
2001	18	24	33	19	18	112
2002	12	20	31	13	14	90
2003	12	20	31	13	14	90
2004	11	21	31	14	13	90
2005	12	19	32	13	14	90
2006	12	20	31	13	14	90
2007	12	20	31	13	14	90
2008	13	22	32	12	11	90
2009	12	20	30	14	14	90
2010	12	20	31	13	14	90
2011	12	20	31	13	14	90
2012	12	20	31	13	14	90
2013	12	20	31	13	14	90
2014	12	20	31	13	14	90

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Catches by haul were standardized to swept area. The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

$Yst = \Sigma (Yi*Ai) / A$

$V(Yst) = \Sigma (Ai^2 * si^2 / ni) / A^2$

Where:

A=total survey area

Ai=area of the i-th stratum

si=standard deviation of the i-th stratum

ni=number of valid hauls of the i-th stratum

n=number of hauls in the GSA

Yi=mean of the i-th stratum

Yst=stratified mean abundance

V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as standard deviation:

Confidence interval = Yst ± V(Yst)

Length distributions represented an aggregation (sum) of all standardized length frequencies (subsamples raised to standardized haul abundance per square kilometers) over the stations of each stratum.

5.2.13.6.1.2 Geographical distribution

Geographical distribution patterns of the stock vary with time; overall the stock appears to be more abundant in the southern part of GSA 18 (Figure 5.2.13.6.1.2.1).

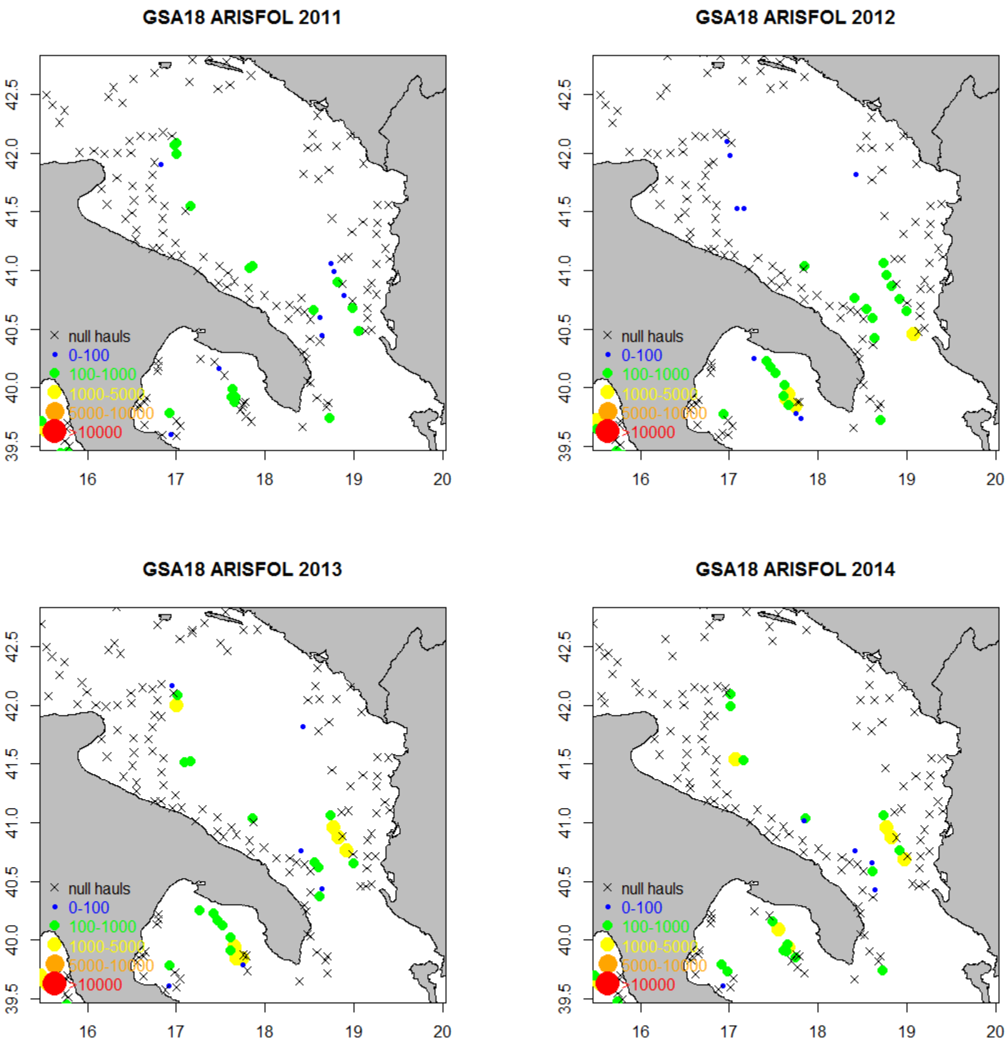


Figure 5.2.13.6.1.2.1. Giant red shrimp in GSA 18. Abundance by haul obtained during the Medits survey in 2011 – 2014.

With regards to critical giant red shrimp habitats in GSA 18, the available information indicates that nuclei of higher abundance of giant red shrimp juveniles tend to be localized off the Gargano Promontory and along the border of the South Adriatic pit. Hot spots of giant red shrimp recruits with higher persistence are mainly localized along the eastern border of the South Adriatic pit offshore the Albania coasts. Recruitment follows a discrete pattern with peak in May. Recruits of giant red shrimp mainly occur at depth between 450 and 550 m, and recruitment size ranges between 17 mm and 29 mm. This area is partially overlapping with a hot spot where spawners are known to aggregate. Both nursery and spawning grounds are characterized by muddy bottom with deep mud biocoenosis and *Isidella elongata* facies. The mainstream current is from south to north (MEDISEH, 2013).

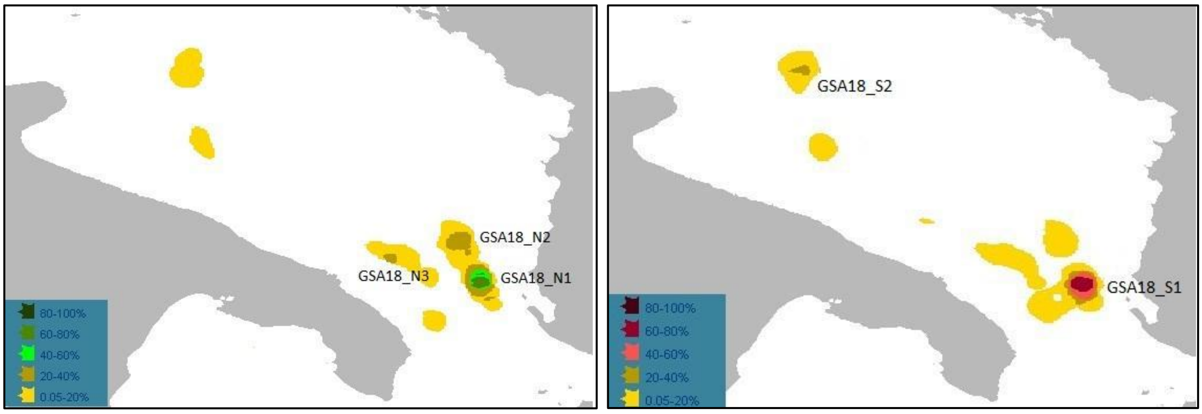


Figure 5.2.13.6.1.2.2. Giant red shrimp in GSA 18. Position of persistent nursery (left) and spawning areas (right) (Source: MEDISEH, 2013).

Based on the available information on the geographic distribution of giant red shrimp populations in GSA 18 in general (Figure 5.2.13.6.1.2.1), critical habitats in particular (Figure 5.2.13.6.1.2.2), and the south to north direction of the mainstream current it is unlikely that there are two separate stocks of giant red shrimp in GSA 18 and 19. Instead the population found in GSA 18 should be considered part of a larger stock distributed in both GSA 18 and GSA 19.

5.2.13.6.1.3 Trends in abundance and biomass

Fishery independent information regarding the state of giant red shrimp in GSA 18 was derived from MEDITS survey data. The estimated abundance and biomass indices are variable, but overall reveal a slightly increasing trend. In 1994-2003 the indices show a steady increase. After 2003 both biomass and abundance indices show remarkable fluctuations, with high indices recorded in 2003, 2007, 2009 and 2013, and low indices recorded in 2007 and 2010. In 2014 both biomass and abundance indices were at intermediate levels

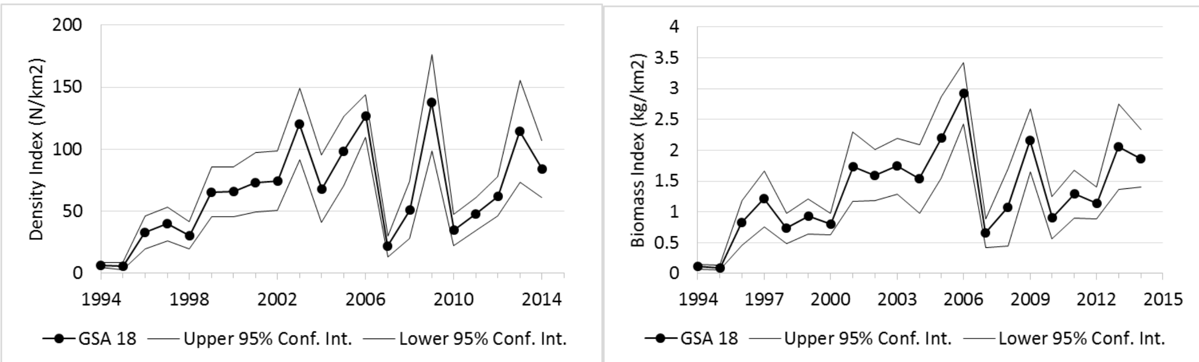


Figure 5.2.13.6.1.3.1. Giant red shrimp in GSA 18. MEDITS trends in biomass and density from 1994 to 2014.

Table 5.2.13.6.1.3.1. Giant red shrimp in GSA 18. MEDITS biomass and density indices from 1994 to 2014.

Year	BI (kg/km2)	DI (N/km2)
1994	0.11	6.74

1995	0.10	5.67
1996	0.82	32.79
1997	1.21	39.82
1998	0.73	30.60
1999	0.93	65.59
2000	0.80	65.72
2001	1.73	73.36
2002	1.60	74.44
2003	1.74	120.34
2004	1.53	68.16
2005	2.20	98.57
2006	2.92	126.83
2007	0.66	21.87
2008	1.07	51.02
2009	2.16	137.54
2010	0.91	35.07
2011	1.29	47.82
2012	1.14	62.13
2013	2.06	114.34
2014	1.87	84.01

5.2.13.6.1.4 Trends in abundance by length or age

The following Figures 5.2.13.6.1.4.1 and 5.2.13.6.1.4.2 display the stratified abundance indices of giant red shrimp in GSA 18 in 1994 - 2014.

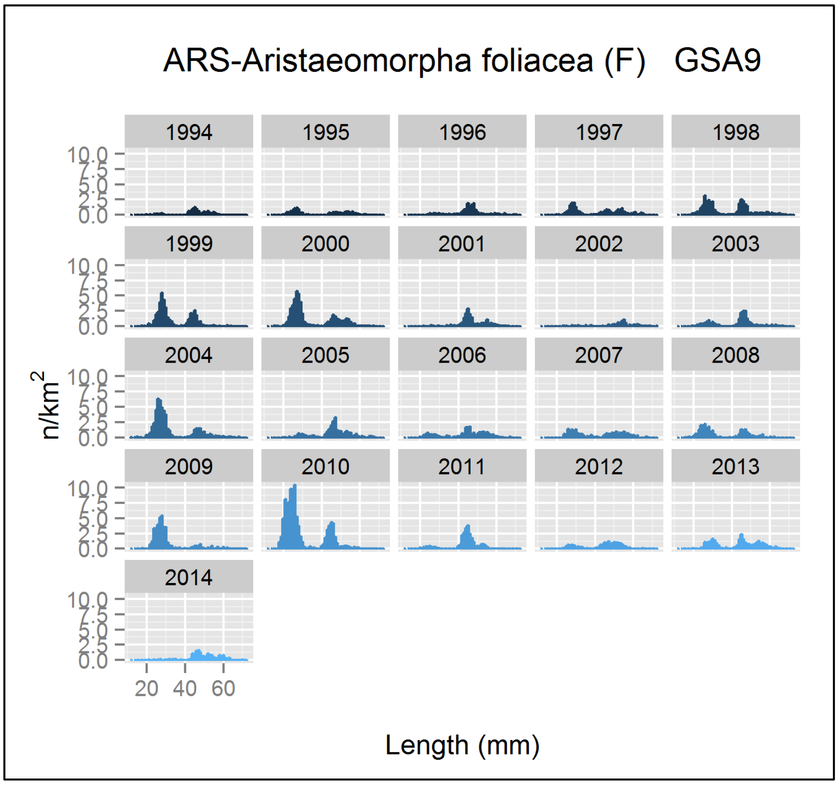


Figure 5.2.13.6.1.4.1. Giant red shrimp in GSA 18. Female stratified abundance indices, 1994-2014.

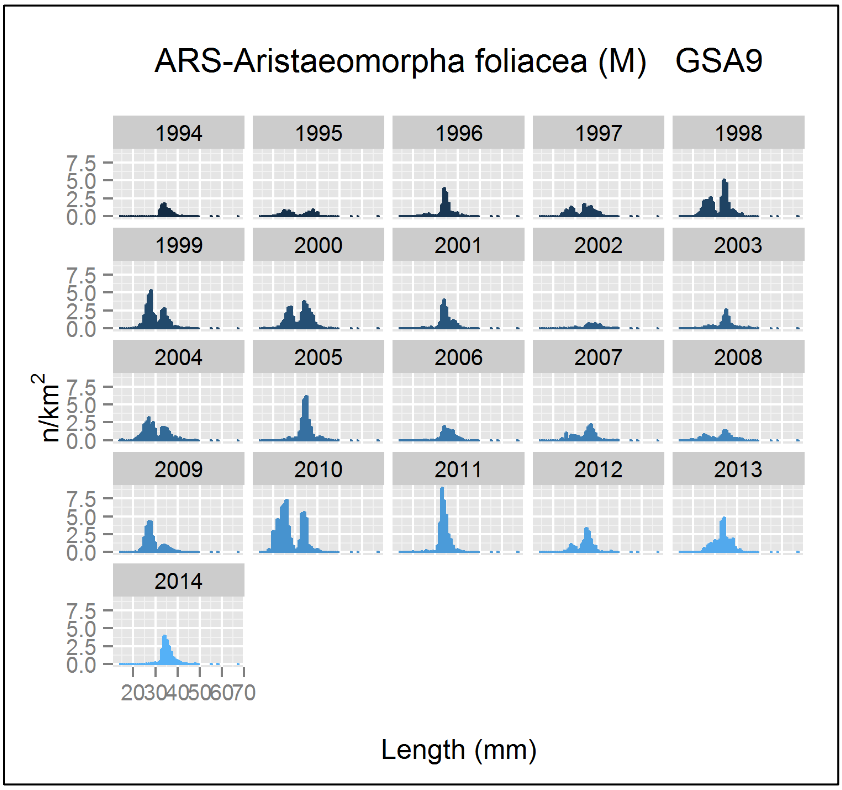


Figure 5.2.13.6.1.4.2. Giant red shrimp in GSA 18. Male stratified abundance indices, 1994-2014.

5.2.13.7 Stock Assessment

5.2.13.7.1 Methods

The assessment of giant red shrimp in GSA 18 was performed during EWG 15-16 in Rome, using an XSA.

5.2.13.7.2 Input data

Data from DCF provided at EWG 15-16, which contained information on giant red shrimp landings and the respective age structure for 2009-2014, were used. In addition catch at age data for 2008 was reconstructed based on (i) official catches recorded through the DCF in GSA 18, and (ii) length frequency distributions recorded through the DCF in the neighbouring GSA 19. Figures 5.2.13.7.2.1 and 5.2.13.7.2.2 show catches in numbers by age from commercial and survey data.

A vector of natural mortality value by age was obtained using ProdBiom (Abella et al., 1997). Medits survey indices used for tuning were obtained by sex and then summed up. There were slight inconsistencies between catches in numbers and weight, so a rescaling using Sum Of Product correction (SOP) was carried out.

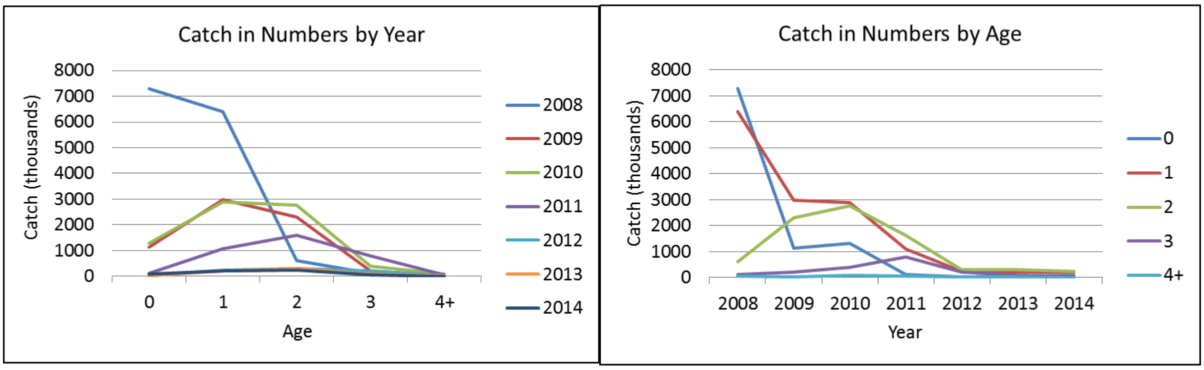


Figure 5.2.13.7.2.1. Giant red shrimp in GSA 18. Catch in numbers by year and age used in the XSA.

Table 5.2.13.7.2.1. Giant red shrimp GSA 18. Catch in numbers by age used in the XSA.

		Year						
		2008	2009	2010	2011	2012	2013	2014
Age	0	7290	1136	1298	109	32	36	82
	1	6395	2983	2878	1083	228	219	197
	2	603	2294	2758	1608	311	307	237
	3	121	214	391	797	206	72	56
	4+	52.4	17	87	55	11	12	4

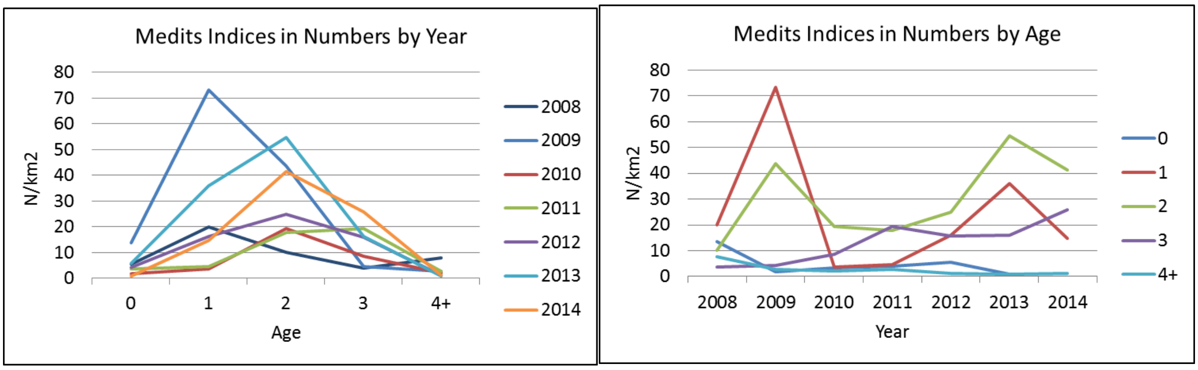


Figure 5.2.13.7.2.2. Giant red shrimp in GSA 18. Catch in numbers by age and year obtained in the Medits survey in 2008-2014 and used in the XSA as tuning data.

Table 5.2.13.7.2.2. Giant red shrimp in GSA 18. MEDITS indices (N/km^2) by age and year used in the XSA as tuning data.

		Year						
		2008	2009	2010	2011	2012	2013	2014
Age	0	5.5	13.6	1.68	3.48	4.12	5.6	0.9
	1	19.9	73.2	3.58	4.62	16	35.9	14.8
	2	10.1	43.6	19.4	17.7	24.8	54.6	41.4
	3	3.83	4.44	8.64	19.4	15.8	16.1	25.8
	4+	7.83	2.64	2.14	2.75	1.24	0.79	1.15

The other inputs are reported in the tables below.

Table 5.2.13.7.2.3. Giant red shrimp in GSA 18. Mean weights at age used in the XSA (both in catch and stock).

Weight at age (kg)	0	1	2	3	4+
2008	0.0050	0.0070	0.0170	0.0230	0.0274
2009	0.0060	0.0110	0.0190	0.0230	0.0247
2010	0.0060	0.0150	0.0230	0.0270	0.0288
2011	0.0070	0.0220	0.0200	0.0210	0.0320
2012	0.0070	0.0170	0.0210	0.0200	0.0248
2013	0.0070	0.0210	0.0250	0.0230	0.0250
2014	0.0070	0.0130	0.0160	0.0190	0.0230

Table 5.2.13.7.2.4. Giant red shrimp in GSA 18. Maturity at age proportions used in the XSA.

Maturity				
Age 0	Age 1	Age 2	Age 3	Age 4+
0	0.6	1	1	1

Table 5.2.13.7.2.5. Giant red shrimp in GSA 18. Natural mortality at age used in the XSA.

Natural mortality				
Age 0	Age 1	Age 2	Age 3	Age 4+
1.17	0.61	0.43	0.36	0.28

Table 5.2.13.7.2.6. Giant red shrimp in GSA 18. Growth and length weight relationships parameters used in PRODBIOM.

	Female	Male
Linf	73	46
K	0.44	0.5
t0	-0.1	-0.1
a	0.0013	2.6419
b	0.0008	2.7845

5.2.13.7.3 Results

XSA was run setting different shrinkage values (Sh1.0, Sh1.5, Sh2.0, Sh2.5 and Sh3.0). As showed by Figure 5.2.13.7.3.1, all shrinkage settings except Sh 1.0 produced similar estimates of recruitment and SSB.

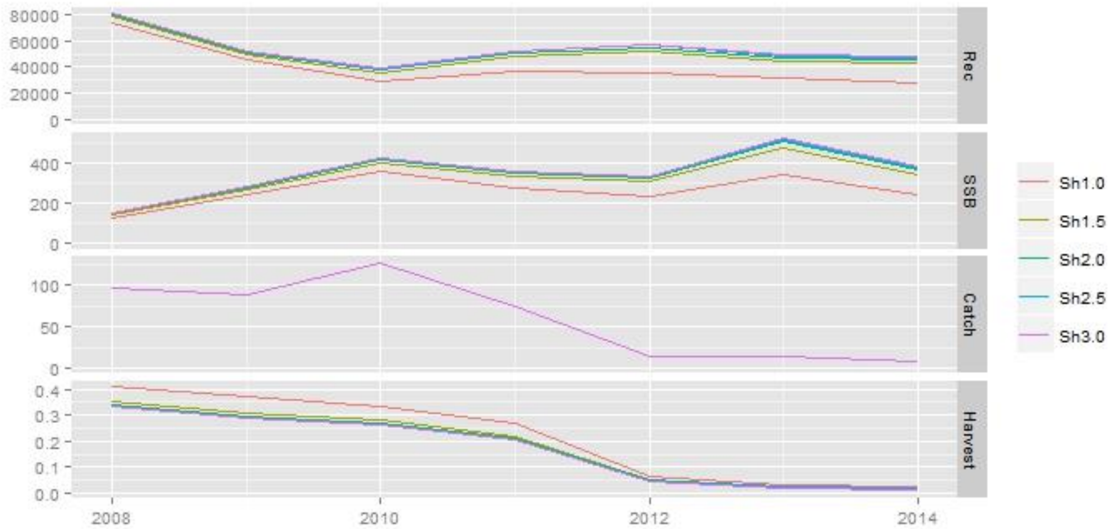


Figure 5.2.13.7.3.1. Giant red shrimp in GSA 18. XSA outputs for different shrinkage scenarios.

The results of the XSA assessment showed a steep decline catches and in fishing mortality from 2008 to 2014, with Fbar in 2014 = 0.02. The reason for such a decline is however most likely due to the fact that the giant red shrimp population in GSA 18 is in fact part of a larger stock distributed in GSA 18 and 19 (see section 5.2.13.6.1.2 for more details on geographical distribution patterns); i.e. giant red shrimp in GSA 18 cannot be considered a separate stock. A joint assessment combining data from GSA 18 and 19 was thus considered more appropriate for this species.

See chapter 5.2.15 for details regarding the joint assessment of giant red shrimp in GSA 18 and 19.

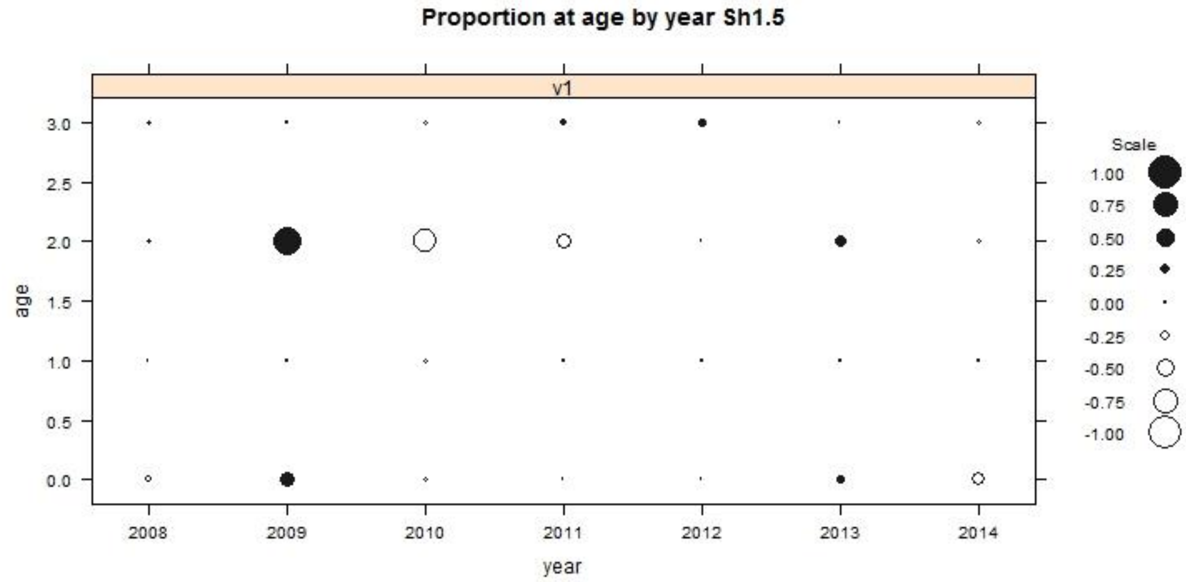


Figure 5.2.13.7.3.2. Giant red shrimp in GSA 18. Log residuals for the tuning fleet.

Model with 1.5 shrinkage and qage2 was adopted as final model based on the analysis of residual distributions. Residuals from tuning fleets (MEDITS) per age and year were relatively low, ranging from 1 to - 1, and did not show any trend with time.

Moreover a retrospective analysis was conducted on recruitment, mean F and SSB (Figure 5.2.13.7.3.3) to ensure the robustness of the final estimates. The retrospective series indicate good agreement between years in the assessment results, with no systematic bias.

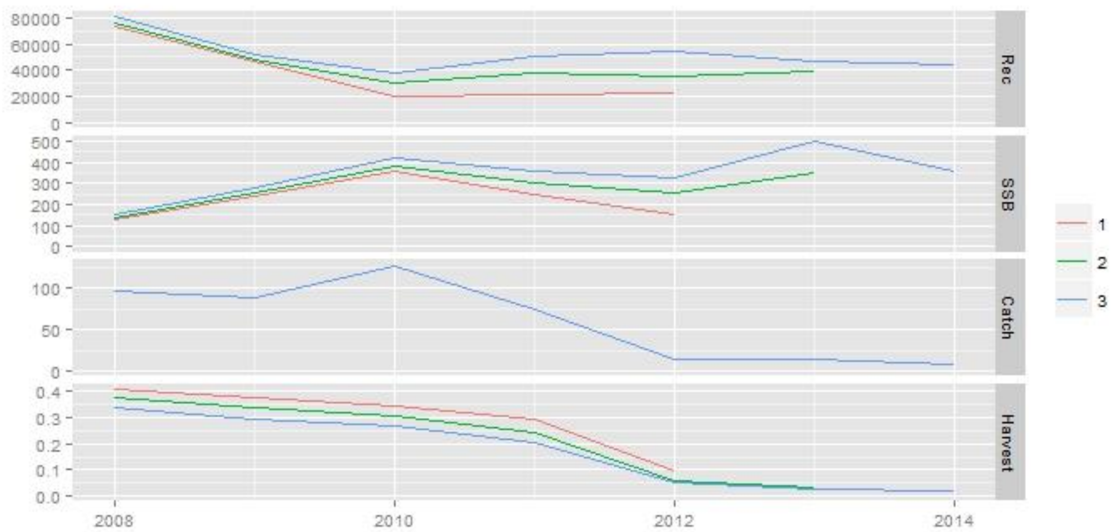


Figure 5.2.13.7.3.3. Giant red shrimp in GSA 18. Retrospective analysis with shrinkage set at 1.5 and qage2.

Based on these simulation analyses, the inputs reported in Table 5.2.13.7.3.1 were selected to run the final XSA.

Table 5.2.13.7.3.1. Giant red shrimp in GSA 18. Inputs selected to run the final XSA.

fse	rage	qage	Shk.n	Shk.f	Shk.yrs	Shk.ages
1.5	1.0	2.0	true	true	5.0	2.0

XSA main outputs (Fig. 5.2.13.7.3.4) showed that F values decreased from around 0.34 in 2008 to 0.02 in 2014. Recruitment varied from a minimum of 37 million in 2010 to a maximum of 81 million in 2009; recruitment in 2014 was 44 million. SSB varied from a minimum of 150 tonnes in 2008 to a maximum of 503 tonnes in 2013; SSB in 2014 was 361 tonnes. XSA stock summary results are reported in the Tab. 5.2.13.7.3.1.

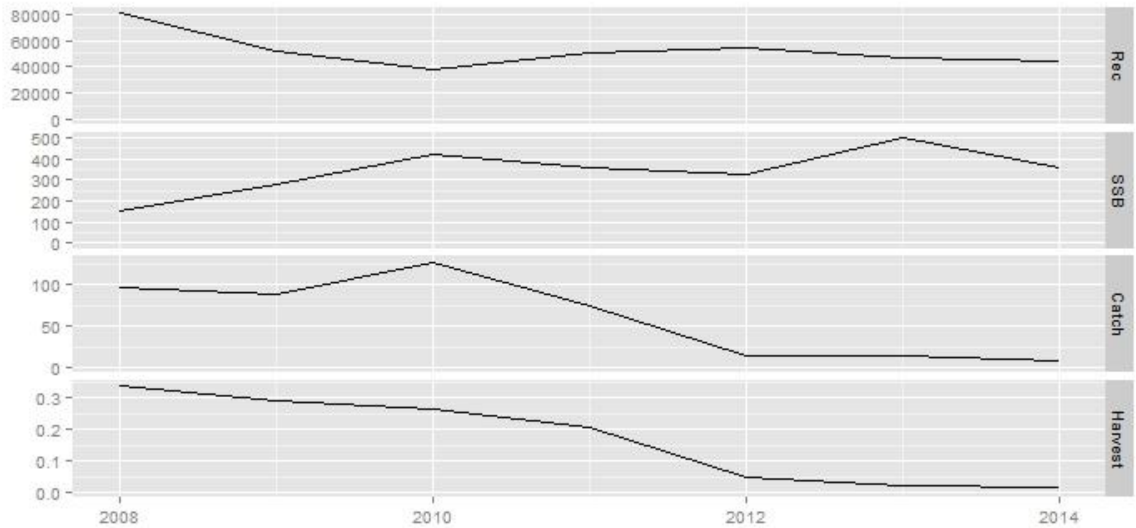


Figure 5.2.13.7.3.4. Giant red shrimp in GSA 18. XSA summary results. SSB and catch are in tons, recruitment in thousands of individuals.

Table 5.2.13.7.3.1. Giant red shrimp in GSA 18. XSA stock summary results. Stock numbers are in thousands of individuals.

SSB	2008	2009	2010	2011	2012	2013	2014
Tons	149.45	280.35	421.88	356.83	326.27	502.95	361.37
Rec	2008	2009	2010	2011	2012	2013	2014
(x1000)	81196	51393	37548	50695	53700	46331	44686
Stock number	2008	2009	2010	2011	2012	2013	2014
0	81196	51393	37548	50695	53700	46331	44686
1	19889	21139	15318	10931	15674	16649	14359
2	2295	6093	9287	6201	5141	8348	8884

3	775	1006	2113	3817	2737	3094	5183
4+	331	78	464	261	149	533	380
F by age	2008	2009	2010	2011	2012	2013	2014
0	0.176	0.040	0.064	0.004	0.001	0.001	0.003
1	0.573	0.213	0.294	0.144	0.020	0.018	0.019
2	0.395	0.629	0.459	0.388	0.078	0.047	0.034
3	0.207	0.294	0.250	0.288	0.094	0.028	0.013
4+	0.207	0.294	0.250	0.288	0.094	0.028	0.013
Fbar	2008	2009	2010	2011	2012	2013	2014
(1-3)	0.34	0.29	0.27	0.21	0.05	0.02	0.02

The XSA diagnostics are reported below:

FLR XSA Diagnostics 2015-12-17 11:57:17

CPUE data from indices

Catch data for 7 years 2008 to 2014. Ages 0 to 4.

fleet first age last age first year last year alpha beta
1 Medits 0 3 2008 2014 <NA> <NA>

Time series weights :

Tapered time weighting applied
Power = 3 over 20 years

Catchability analysis :

Catchability independent of size for ages > 1

Catchability independent of age for ages > 2

Terminal population estimation :

Survivor estimates shrunk towards the mean F
of the final 5 years or the 3 oldest ages.

S.E. of the mean to which the estimates are shrunk = 1.5

Minimum standard error for population
estimates derived from each fleet = 0.3

prior weighting not applied

Regression weights
year
age 2008 2009 2010 2011 2012 2013 2014
all 0.921 0.954 0.976 0.99 0.997 1 1

Fishing mortalities
year
age 2008 2009 2010 2011 2012 2013 2014

```
  0 0.176 0.040 0.064 0.004 0.001 0.001 0.003
  1 0.573 0.213 0.294 0.144 0.020 0.018 0.019
  2 0.395 0.629 0.459 0.388 0.078 0.047 0.034
  3 0.207 0.294 0.250 0.288 0.094 0.028 0.013
  4 0.207 0.294 0.250 0.288 0.094 0.028 0.013


 XSA population number (Thousand)
     age
year      0     1    2    3   4
  2008 81196 19889 2295  775 331
  2009 51393 21139 6093 1006  78
  2010 37548 15318 9287 2113 464
  2011 50695 10931 6201 3817 261
  2012 53700 15674 5141 2737 149
  2013 46331 16649 8348 3094 533
  2014 44686 14359 8884 5183 380


 Estimated population abundance at 1st Jan  2015
     age
year             0     1    2    3    4
  2015 6.980857e+194 13901 7691 5612 3588


 Fleet:  Medits

 Log catchability residuals.

   year
age   2008   2009   2010   2011   2012   2013   2014
  0 -0.110  0.364 -0.054 -0.019 -0.003  0.162 -0.333
  1 -0.024  0.030 -0.080  0.016  0.000  0.037  0.017
  2  0.085  0.721 -0.616 -0.345 -0.014  0.269 -0.078
  3  0.044 -0.014 -0.117  0.121  0.129 -0.014 -0.070

 Regression statistics
 Ages with q dependent on year class strength
[1] "0.530886525635114" "0.254415844851144" "9.74754769952547"
[4] "8.85529277505604"


 Terminal year survivor and F summaries:

 ,Age 0 Year class =2014

source
      scaledWts survivors yrcls
Medits     0.126      7387  2014
fshk      0.018      1928  2014
nshk      0.856     15901  2014

 ,Age 1 Year class =2013

source
      scaledWts survivors yrcls
Medits     0.961      8199  2013
fshk      0.039       961  2013

 ,Age 2 Year class =2012

source
      scaledWts survivors yrcls
Medits     0.912      5169  2012
fshk      0.088       496  2012

 ,Age 3 Year class =2011

source
      scaledWts survivors yrcls
```

Medits 0.961 3329 2011
fshk 0.039 2495 2011
NULL

5.2.13.8 Reference points

5.2.13.8.1 Methods

To predict the effect of changes in fishing effort of future yields and to define reference points F_{01} (as a proxy for F_{MSY}) and F_{max} a Yield per Recruit analysis (YPR) was carried out in R.

5.2.13.8.2 Input data

As input the same population parameters used for the XSA and its output of the exploitation pattern were used.

5.2.13.8.3 Results

The estimated reference point, $F_{0.1}$ = 0.484.

Table 5.2.13.8.3.1. Giant red shrimp in GSA 18. Main reference points defined with the Yield per recruit analysis.

harvest	yield	rec	ssb	biomass	revenue
virgin	0.00	0.00	1.00	0.02	0.03
msy	3.18E+120	0.01	1.00	0.00	0.01
crash	70.17	0.01	1.00	0.00	0.01
f0.1	0.48	0.00	1.00	0.01	0.02
fmax	7.97E+16	0.01	1.00	0.00	0.01
spr.30	0.84	0.00	1.00	0.00	0.01

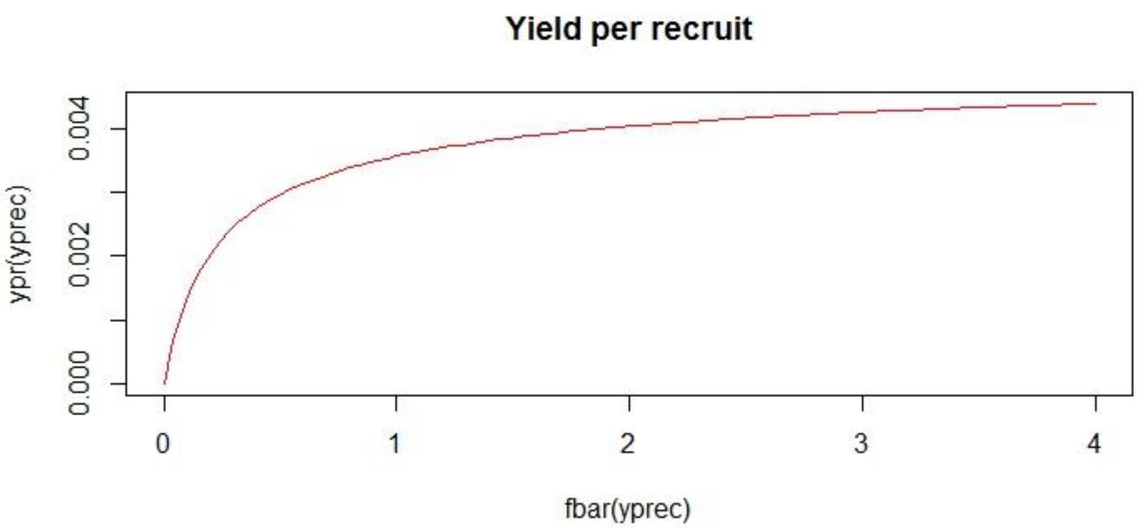


Figure 5.2.13.8.3.1. Giant red shrimp in GSA 18. Yield per recruit curve.

5.2.13.9 Data quality

Landings data for 2003 appears to be at least partly erroneous since 12.7 tonnes of giant red shrimp caught by set gillnets (GNS) were reported by the Italian authorities.

Except for 2009 and 2011 no data on total discard weights or discards length frequency distributions were reported through the official DCF.

Data on mesh size were available for 2004 to 2008 (40D50) and 2012 to 2014 (50D100); no information on mesh size is available for 2009 to 2011. As a result it is not possible to interpret the available information on discard length frequencies (discard CL range in 2009 is 19-30 mm; in 2011 it is 14-19 mm).

5.2.13.10 Short term predictions 2015-2017

No short term preditions were estimated for giant red shrimp in GSA 18 since an independent assessment of GSA 18 was not considered to be a suitable approach.

5.2.13.11 Medium term predictions

No medium term preditions were estimated for giant red shrimp in GSA 18 since an independent assessment of GSA 18 was not considered to be a suitable approach.

5.2.13.12 Stock advice

No stock advice is given for giant red shrimp in GSA 18 since an independent assessment of GSA 18 was not considered to be a suitable approach.

5.2.13.13 Management strategy evaluation

No management strategy evaluation was performed for for giant red shrimp in GSA 18 since an independent assessment of GSA 18 was not considered to be a suitable approach.

5.2.14 STOCK ASSESSMENT OF GIANT RED SHRIMP IN GSA 19

5.2.14.1 Stock Identification

The GSA 19 (North-Western Ionian Sea) is located between Cape Otranto and Cape Passero. This area covers a surface of about 16,500 km^2 in the depth range from 10 to 800 m and has a coast line of about 1,000 km along the Apulia, Basilicata, Calabria and Sicily regions, where 8 maritime compartments are located. The North-Western Ionian Sea is geo-morphologically divided in 2 sectors by the Taranto Valley (NW-SE canyon exceeding 2200 m in depth). Along the Calabria and Sicily, the shelf is generally very limited with the shelf break located at a depth varying between 30 and 100 m. Different biocenosis are distributed along the very long Ionian arc from the coastal to the bathyal grounds. Along the Apulia coast the shelf is generally wider and the biocenosis of coralligenous is widespread from 40 to 80 m in depth.

In both sectors of the North-Western Ionian Sea, some shallower ground sites are characterized by the biocenosis of coarse-grained sands and fine gravels under bottom currents (SGCF) and superficial muddy sands in sheltered areas (SVMC). On the shelf edge, there are some areas with the biocenosis of the shelf-edge detritic often characterized by the dominance of the sea-lily *Leptometra phalangium*, while over the continental slope the biocenosis of the bathyal mud extends in the whole Ionian Sea.

As well as in the rest of the Mediterranean, the giant red shrimp is distributed on the shelf-break and upper slope in the GSA19.

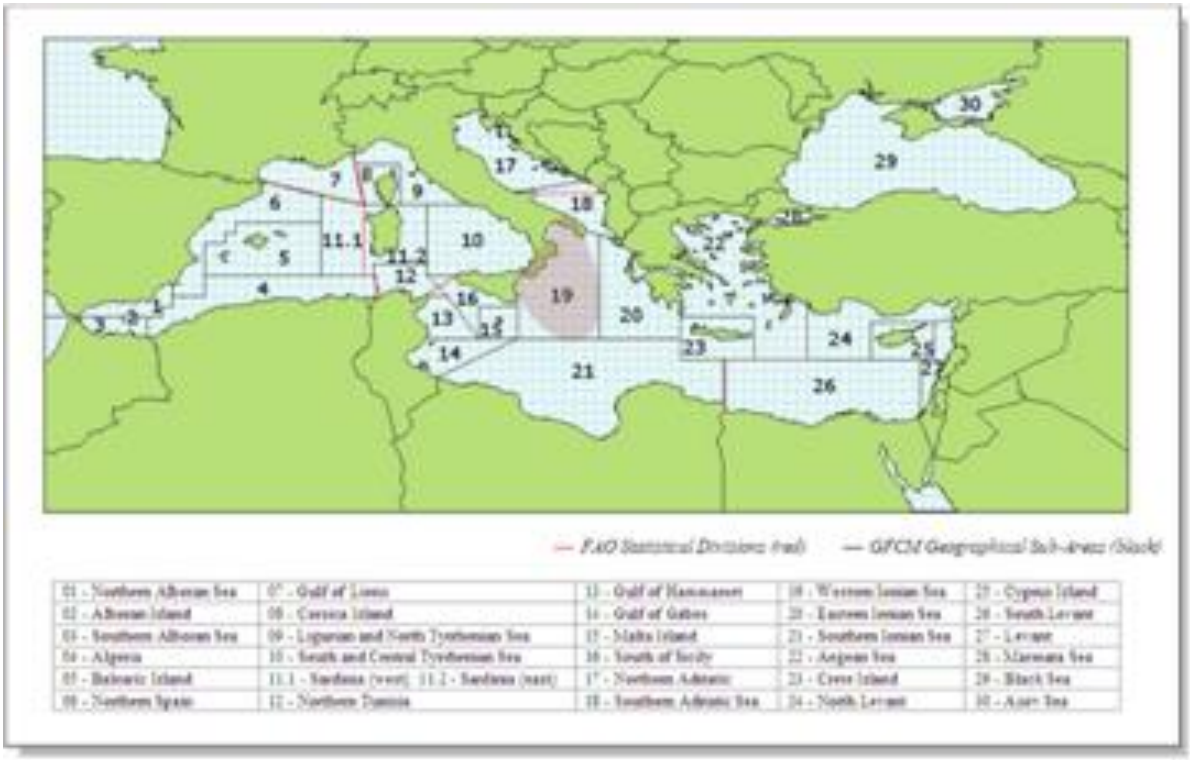


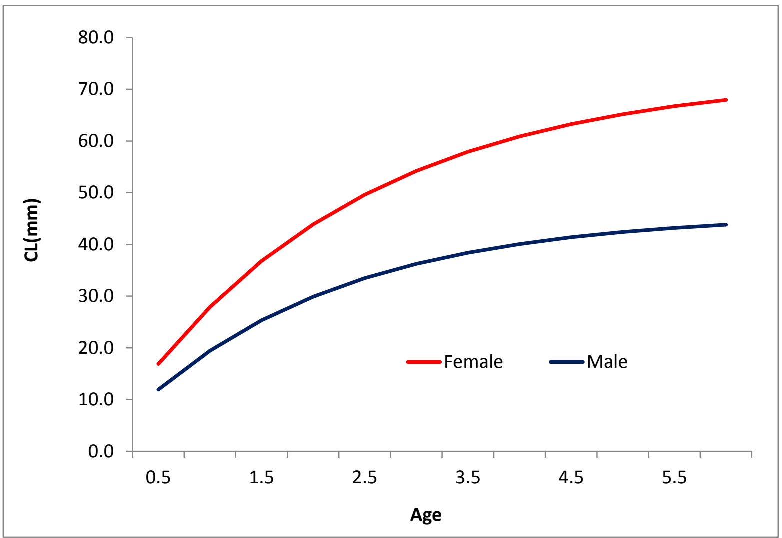
Fig. 5.2.14.1.1. Geographic localisation of GSA 19.

The main outcomes of the EU StockMed project carried out in MAREA framework validated a degree of genetic differentiation among the Mediterranean local samples. However, when Mediterranean samples were grouped in western and eastern basins, the variation among groups was not statistically significant. Thus, no definition of unit stocks neither based on genetics, bio-chemistry, fishery-based nor on morphometric parameters are currently available for the species. Up to date, the hypothesis of a single stock of the giant red shrimp in GSA 19 seems almost unlikely, mainly due to geo-morphological and hydrographic features in the North-Western Ionian Sea. However, under a management point of view, when the lack of any experimental evidence does not allow any alternative hypothesis, it is assumed that inside each of the GSAs boundaries inhabits a single, homogeneous stock that behaves as an unique well-mixed and self-perpetuating population. As matter of fact, the GSA boundaries are arbitrary and do not take under consideration neither the existence of local biological features nor differences in the spatial allocation of fishing pressure. Thus, the inability to take into account for spatial structure might lead to uncertainty in the definition of the status of the stocks, due to the possibility of local depletions, and to a worse utilization of the potential productivity of the resources.

5.2.14.2 Growth

In the framework of the experimental trawl surveys carried out in the GSA 19 the giant red shrimp was caught at depth ranging from 127 to 1145 m (Maiorano *et al.*, 2010). The minimum and maximum sizes for *A. foliacea* in GSA 19 during the MEDITS and GRUND surveys were 8.0 and 69.0 mm CL, respectively. The growth parameters as well as the estimated length-weight relationship from DCF were available by sex: CL_{∞}=73.24 mm, K=0.438, t_0= -0.1 for females and CL_{∞}=46.00 mm, K=0.500, t_0= -0.1 for males.

Average parameters of the length-weight relationship were a=0.00126, b=2.65 for females and a=0.00106, b=2.73 for males, for length expressed in mm.



	females	males
CL_{∞} (mm)=	73.0	46.0
k/year=	0.438	0.5
t_0(year)=	-0.1	-0.1

Fig. 5.2.14.2.1. Giant red shrimp in GSA 19. Von Bertalanffy growth functions and parameters for the two sexes.

5.2.14.3 Maturity

The giant red shrimp is a seasonal iteroparous with a reproductive period somewhat extended, starting in spring and peaking during summer in GSA 19 (D'Onghia *et al.*, 1998, 2012). The sizes of recruitment ranged between 18 and 27 mm CL (Tursi *et al.*, in Lembo, coord., 2010). The smallest mature female and male in the North-Western Ionian Sea were 20 and 13 mm CL, respectively. The size at maturity estimated was 36 mm CL for females and 28 mm CL for males respectively.

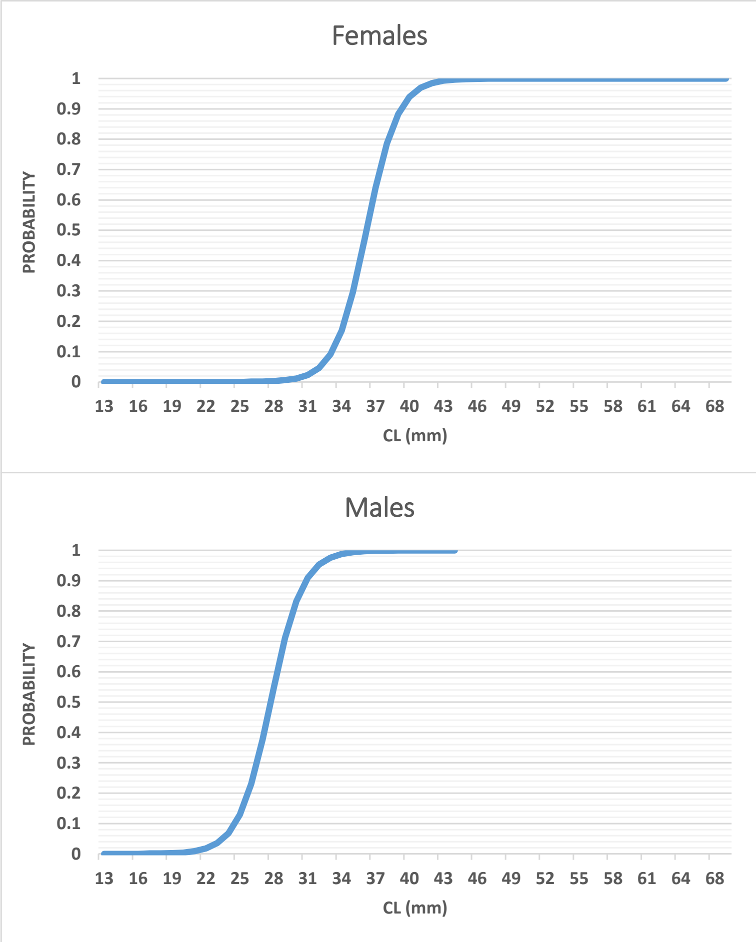


Fig. 5.2.14.3.1. Giant red shrimp in GSA 19. Maturity ogives of mature females (above) and males (below).

The sex ratio from DCF evidenced the prevalence of males in the size classes from 20-25 mm CL to 32-33 mm CL depending from the period considered. From 34 mm CL onwards the proportion of females was dominant (Figure 5.2.14.3.2).

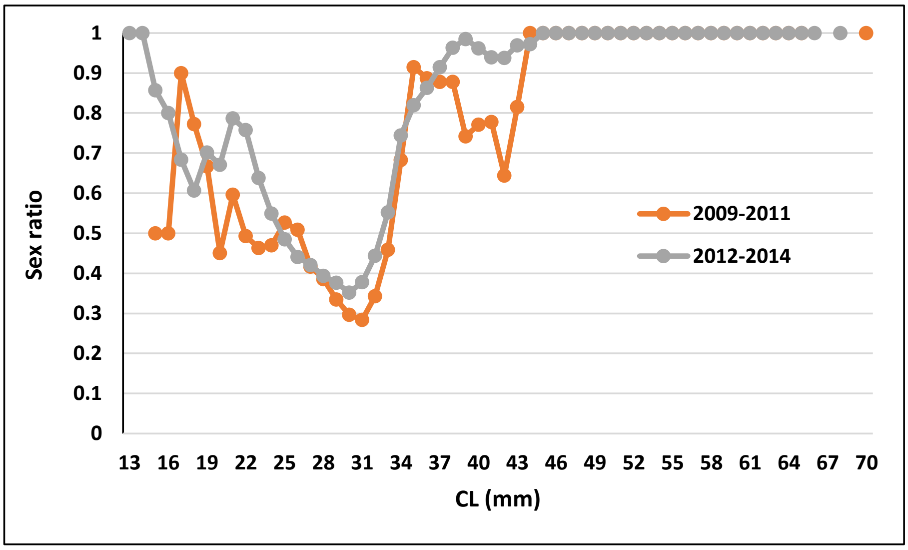


Fig. 5.2.14.3.2. Giant red shrimp in the GSA 19. Sex ratio.

5.2.14.4 Natural mortality

A vector of natural mortality by age was estimated. The results are shown in Table 5.2.14.4.1. The vector is estimated as mean of two vectors computed using PRODBIOM (Abella *et al*., 1998) by sex. The input parameters used for M estimation were Linf = 73, k = 0.438, t_0 =-0.1, a = 0.00126 and b = 2.65 for females and Linf = 46, k = 0.5, t_0 =-0.1, a = 0.00106 and b = 2.73 for males.

Table 5.2.14.4.1. Giant red shrimp in GSA 19. Natural mortality by age.

age 0	age 1	age 2	age 3	Age 4+
1.21	0.63	0.44	0.37	0.29

5.2.14.5 Fisheries

5.2.14.5.1 General description of the fisheries

The giant red shrimp, *Aristaeomorpha foliacea*, is one of the most important target species of the mixed demersal deep-water trawling carried out on the upper-middle continental slope of the GSA19. In particular, together with *A. antennatus*, the catches of *A. foliacea* could contribute up to 100% of the total income, mainly in the Gallipoli marine district (Carlucci *et al*., 2002).

In general, the maritime compartments where trawling is highly representative in the GSA19 were Gallipoli, Taranto, Crotone e Reggio Calabria, however different dimensional classes were observed in fishing effort (LFT, GT) and engine power (kW) (Maiorano *et al*., 2010). National official statistics (IREPA, 2009) indicated as the highest percentage of vessel with higher LFT (≥ 10 GT) is mostly concentrated in the maritime compartments of Crotone (44%) and Reggio Calabria (21%), whilst a reduced percentage was recorded in Gallipoli (24%) and Taranto (11%), where vessels are generally smaller with LFT < 10 GT (Tursi *et al*., 2011). On the structural point of view, the trawling fleet along the Calabrian and Apulian coasts counted 225 vessels for a total amount of 4000 GT and 30000 kW. Generally, trawling occurred with daily trip (Gallipoli, Taranto, Crotone), with the exception of the fleet working around Roccella Ionica (Reggio Calabria), where fishing trip lasted 2-3 days (Tursi *et al*., 2011). During spring and summer months a higher number of working days were recorded for trawling in GSA19, whilst during autumn and winter the bad sea-weather conditions could influence the displacement of the fishing effort on very coastal areas rather than on deep water grounds.

5.2.14.5.2 Management regulations applicable in 2015

Management regulations are based on technical measures, closed number of fishing licenses for the fleet and area limitation (distance from the coast and depth). In order to limit the over-capacity of fishing fleet, the Italian fishing licenses have been fixed since the late eighties. Other measures on which the management regulations are based regard technical measures (mesh size) and minimum landing sizes (EC 1967/06).

In details, the main regulations are:

- ✓ Fishing closure for trawling: 45 days in late summer early autumn (not every year the same).
- ✓ Cod end mesh size of trawl nets: 40 mm (stretched, diamond meshes) till 30/05/2010. From 1/6/2010 the existing nets have been replaced with a cod end with 40 mm (stretched) square meshes or a cod end with 50 mm (stretched) diamond meshes.

- ✓ Towed gears are not allowed within 3 nm from the coast or at depths less than 50 m when this depth is reached at a distance less than 3 miles from the coast.

5.2.14.5.3 Catches

The catch is composed almost esclusively by marketed individuals.

5.2.14.5.4 Landings

Available landing data are from DCF regulations. EWG 15-16 received Italian landings data for GSA19 by fisheries which are listed in Table 5.2.14.5.4.1.
In general, demersal trawlers account for the majority of the total landing. Small amounts are due to some artisanal vessels fishing with gillnet and trammel net (Figure 5.2.14.5.4.1). Those fisheries contribute from 0 to 1.8% to the total landing according to the different years.
Landings showed an evident increasing trend starting from 2008. The maximum values were registered in 2011 and 2013. The main fraction of the landings was due to the deep sea bottom otter trawl fishery (OTB_DWS).
The size frequency distributions of the trawl landing are comprised between 10 and 67 mm CL and show different modal classes (Figure 5.2.14.5.4.2).

Table 5.2.12.5.4.1. Giant red shrimp in GSA 19. Annual landings (tons) by fishery, from 2004 to 2014.

Year	Gear	Fishery	Landings
2004	GNS	DEMF	1.1
2004	OTB	-1	61.8
2005	OTB	MDDWSP	54.7
2006	OTB	DWSP	36.7
2006	OTB	MDDWSP	199.8
2007	OTB	DWSP	97.1
2007	OTB	MDDWSP	101.5
2008	OTB	-1	132.6
2009	OTB	DWSP	83.9
2009	OTB	MDDWSP	142.0
2010	OTB	MDDWSP	124.0
2010	OTB	DWSP	177.5
2011	OTB	DWSP	232.3
2011	OTB	MDDWSP	114.5
2012	OTB	MDDWSP	96.2
2012	GTR	DEMSP	1.4
2012	OTB	DWSP	164.7
2013	GTR	DEMSP	2.3
2013	OTB	DWSP	233.8
2013	OTB	MDDWSP	112.8
2014	OTB	DWSP	250.6
2014	OTB	MDDWSP	69.4

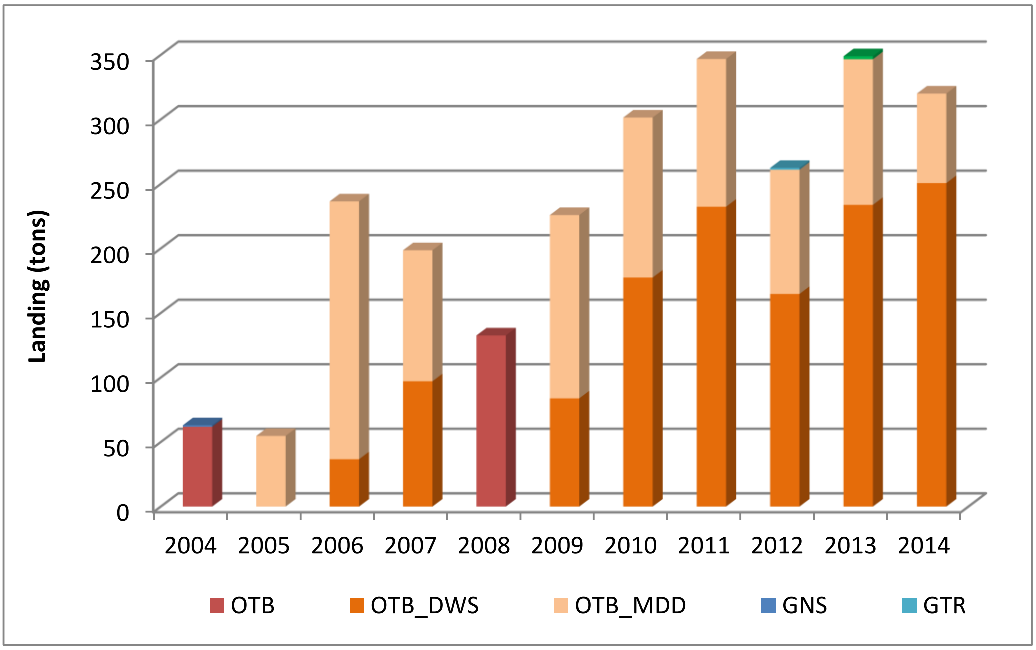


Fig. 5.2.14.5.4.1. Giant red shrimp in the GSA 19. Annual landings (tons) from 2004 to 2014.

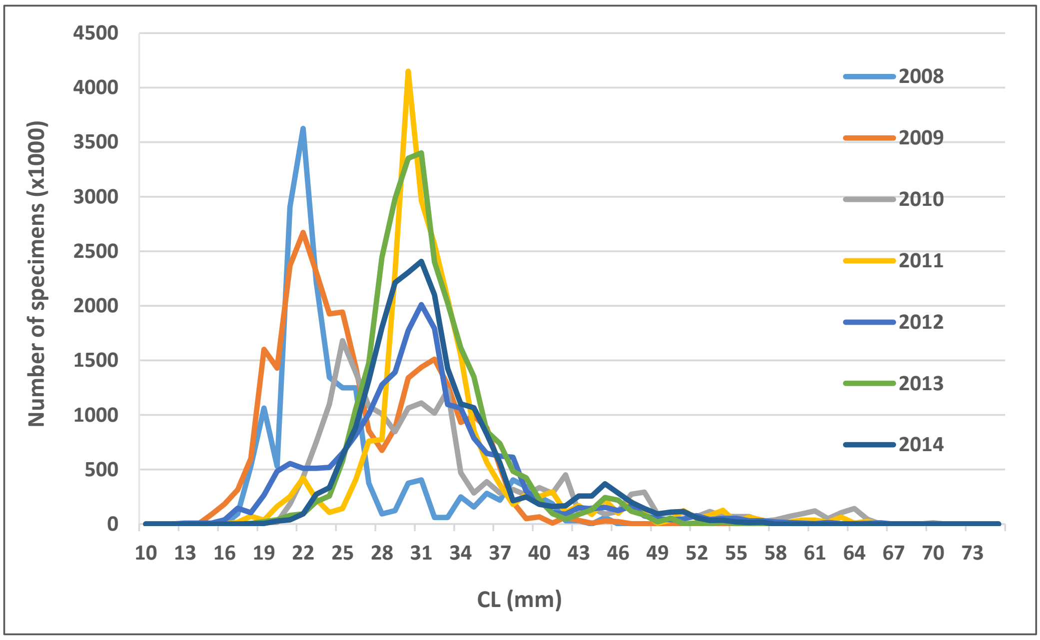


Fig. 5.2.12.5.4.2. Giant red shrimp in the GSA 19. Demographic structure of the trawl landing from 2008 to 2014.

5.2.14.5.5 Discards

Discards were observed only in 2009 (5.3 tons) and 2012 (1.8 tons). The proportion of the discards of the giant red shrimp in the GSA 19 was generally negligible: 2.3% of the total catch in 2009 and 1.1% in 2012.

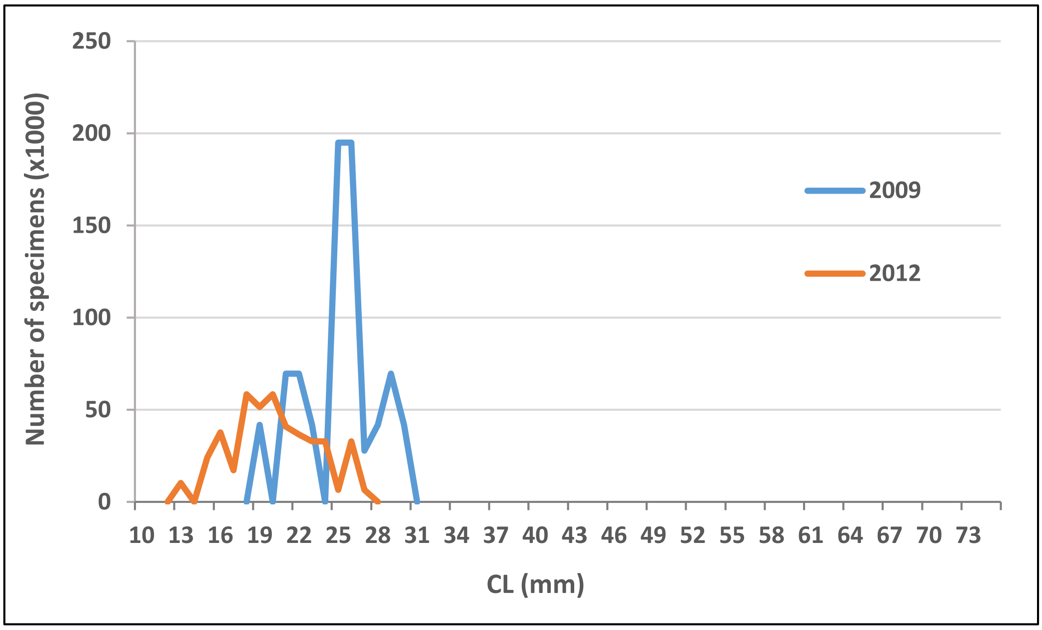


Fig. 5.2.14.5.5.1. Giant red shrimp in GSA 19. Demographic structure of the trawl discard for 2009 and 2012.

5.2.14.5.6 Fishing effort

The trends in fishing effort by year and “metier” in terms of kW*days and GT*days are listed in Tables 5.2.14.5.6.1-2, respectively.

Table 5.2.14.5.6.1. Nominal effort (kW*days) for the GSA 19 by “metier”, 2002-2014 as reported through the DCF official data call.

Gear	Metier	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Miscellanea	-1	13116917	9143878	1213443	973855	1575591	1716387	1011725	2280755	3232894	1823709	481263	153381	168573
Miscellanea	CEP			10633	6075	119011	27782	98751	70967	56780	113239	19827		34817
Miscellanea	DEMSP			194876	101595	81983	2877	15617	76195	454747	120572	39245	266688	206756
Miscellanea	FINF						910				730			
FPO	DEMSP			378783	56433	54555	43143	232619	306303	284107	166250	270169	153144	133392
GND	SPF			728507	222428	505277	270396	239342	256486	610146	527523	559590	53176	115664
GNS	DEMSP			797996	1197159	1402176	1473754	1275650	1441596	1813781	1705748	1627697	2394257	2065333
GNS	SLPF				19980		5779	24654	14979	35862	33685	65428	659511	310726
GTR	-1	4669873	9192254											
GTR	DEMSP			2742293	2115507	1106682	925004	1131865	1653130	1896850	1777574	1590170	3379761	2358945
LLD	LPF			5367540	6420870	4414699	4431347	5603064	3987741	4245026	2453384	3916244	3885256	3835537
LLS	DEMF			1143710	861956	870853	1062369	620865	679391	852696	1056634	1307624	2054032	1763634
LTL	LPF				111047	155819	23117	33950						
OTB	-1	5125805	5002396											
OTB	DEMSP			1094525	410650	453739		1801875	1960993	1475146	1649360	1392229	426118	601834
OTB	DWSP					417516	369943	603067	782787	1135159	1166121	1618604	1475193	1841870
OTB	MDDWSP			4780949	3771349	5899222	4942437	2945984	3617237	4035392	4016748	3371838	4227546	3583299
OTM	MDPSP										9781	317792		
PS	-1	978456.9	1629677											
PS	LPF			12888	58650	70670	104774	87337	235232	205508	223757	301915	201187	132990
PS	SPF			1551236	1593636	826254	792624	1365216	555792	559705	517299	712759	413868	378181
PTM	SPF					11424					13898			

Table 5.2.14.5.6.2. Fishing effort (GT*days) for the GSA19 by "metier", 2002-2014 as reported through the DCF official data call.

Gear	Metier	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Miscellanea	-1	NA	NA	142395	118179	168962	173782	113784	338621	468766	268707	59771	14034	16870
Miscellanea	CEP	NA	NA	7764	4179	8020	5225	12358	9228	7597	10600	1936		3867
Miscellanea	DEMSP	NA	NA	21425	10638	11377	2369	1111	9049	64192	13319	7049	19250	18786
Miscellanea	FINF	NA	NA		513	103	111	28			123			
FPO	DEMSP	NA	NA	11474	3134	3393	2538	7528	13909	8993	5670	15718	12862	10551
GND	SPF	NA	NA	39238	26426	46130	27170	20575	10122	32023	27984	30215	3547	12317
GNS	DEMSP	NA	NA	78308	99557	123299	122942	96348	106178	130783	115096	108264	142700	143124
GNS	SLPF	NA	NA		2311		847	2196	1316	3331	2753	6453	40857	18814
GTR	DEMSP	NA	NA	233891	197023	104406	88113	102936	141967	149802	140997	130340	243041	182299
LLD	LPF	NA	NA	992388	1086458	806070	804784	892144	595411	583783	425801	555414	684044	532179.5
LLS	DEMF	NA	NA	110883	69009	68640	89442	64130	68039	71070	101916	128798	159044	151206
LTL	LPF	NA	NA		9999	14561	1902	3598				206		
OTB	DEMSP	NA	NA	172918	58896	54251		241580	259945	201051	243988	204367	44112	85357
OTB	DWSP	NA	NA			35607	45377	55244	68060	125118	135685	176305	125260	168069
OTB	MDDWSP	NA	NA	588149	371357	582678	446565	277542	383614	434148	425742	404563	452580	362067
OTM	MDPSP	NA	NA								1454	43747		
PS	LPF	NA	NA	973	4987	4236	7370	5589	19034	14638	27070	28574	33569	19700
PS	SPF	NA	NA	207363	185988	127961	102554	178648	62624	67853	84273	111089	50250	56139
PTM	SPF	NA	NA	820		1478					3012			

The giant red shrimp is quite esclusively caught by trawlers fishing for mixed demersal and deep water species (OTB_MDDWSP) and deep water species (OTB_DWSP). The fishing effort of those trawlers is shown in Figure 5.2.14.5.6.1. OTB_DWS was characterised by a gradual increase along the time series, while OTB_MDDWSP, after initial fluctuations, remained quite constant in the period 2010-2014. The total effort of the two "metiers" combined showed fluctuations in the first years and a constant or slight increasing trend in the period 2010-2014.

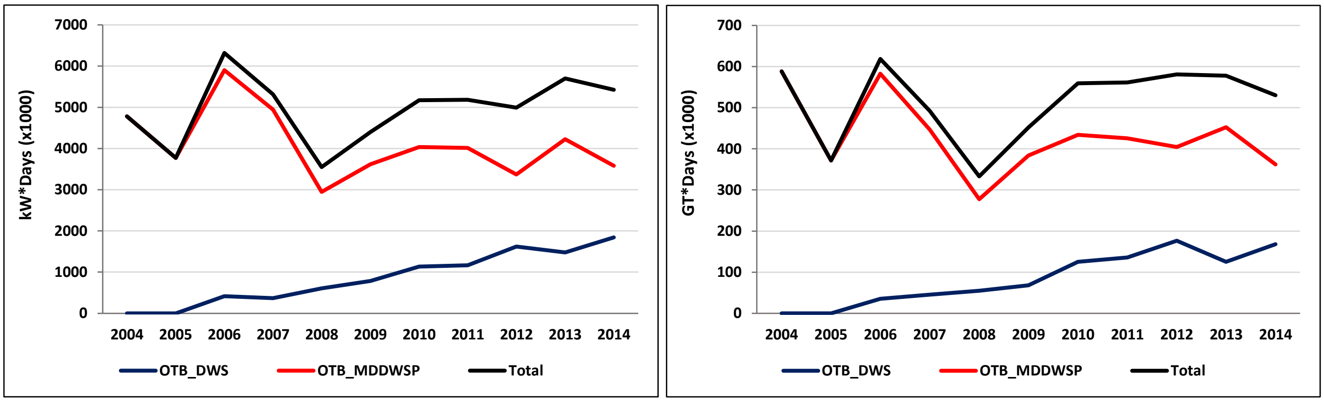


Fig. 5.2.14.5.6.1. Trends of the fishing effort of the OTB "metiers" targeting giant red shrimp in the GSA 19.

5.2.14.6 Scientific surveys

5.2.14.6.1 MEDITS

5.2.14.6.1.1 Methods

According to the MEDITS protocol (Bertrand *et al.*, 2002), trawl surveys were yearly (May-July) carried out, applying a random stratified sampling by depth (5 strata with depth limits at: 50, 100, 200, 500 and 800 m; each haul position randomly selected in small sub-areas and maintained fixed throughout the time). Haul allocation was proportional to the stratum area. The same gear (GOC 73,

by P.Y. Dremière, IFREMER-Sète), with a 20 mm stretched mesh size in the cod-end, was employed throughout the years. Detailed data on the gear characteristics, operational parameters and performance are reported in Dremière and Fiorentini (1996). Considering the small mesh size a complete retention was assumed. All the abundance data (number of fish and weight per surface unit) were standardised to square kilometre, using the swept area method.
Based on the DCF data call, abundance and biomass indices were recalculated with a standardization to the hour. In GSA 19 the following number of hauls was reported per depth stratum (Table 5.2.14.6.1.1.1).

Table 5.2.14.6.1.1.1. Number of hauls per year and depth stratum in the GSA 19, 1994-2014.

Stratum	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
10-50	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
50-100	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
100-200	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
200-500	15	15	15	15	15	15	15	15	14	14	14	15	14	14	14	14	14	14	14	14	14
500-800	32	32	32	32	32	32	32	32	29	29	29	28	29	29	29	29	29	29	29	29	29
10-800	74	74	74	74	74	74	74	74	70	70	70	70	70	70	70	70	70	70	70	70	70

Fig. 5.2.14.6.1.1.1. Map of MEDITS hauls positions in GSA 19.

Data were assigned to strata based upon the shooting position and average depth (between shooting and hauling depth). Catches by haul were standardized to 60 minutes hauling duration. Hauls noted as valid were used only, including stations with no catches (zero catches are included).
The abundance and biomass indices by GSA were calculated through stratified means (Cochran, 1953; Saville, 1977). This implies weighting of the average values of the individual standardized catches and the variation of each stratum by the respective stratum areas in each GSA:

$Yst = \Sigma (Yi*Ai) / A$

$V(Yst) = \Sigma (Ai^2 * si^2 / ni) / A^2$

Where:

A=total survey area
Ai=area of the i-th stratum
si=standard deviation of the i-th stratum
ni=number of valid hauls of the i-th stratum
n=number of hauls in the GSA
Yi=mean of the i-th stratum
Yst=stratified mean abundance
V(Yst)=variance of the stratified mean

The variation of the stratified mean is then expressed as the 95 % confidence interval: Confidence interval = Yst ± t(student distribution) * V(Yst) / n
It was noted that while this is a standard approach, the calculation may be biased due to the assumptions over zero catch stations, and hence assumptions over the distribution of data. A normal distribution is often assumed, whereas data may be better described by a delta-distribution and/or quasi-poisson. Indeed, data may be better modeled using the idea of conditionality and the negative binomial (e.g. O'Brien et al. (2004)).
Length distributions represent the number of individual per km^2 (Cochran, 1977).

5.2.14.6.1.2 Geographical distribution

The geographical distribution pattern of the giant red shrimp has been studied in the area using MEDITS trawl-survey data, length frequency distribution analyses via modal component separation techniques and geostatistical methods. Some analysis and output for both recruits and spawners were available in the contest of the EU Mediseh project carried out in MAREA framework (Figure 5.2.14.6.1.2.1). The main nursery areas were frequently observed on the upper slope grounds distributed along the coast from Santa Maria di Leuca to Gallipoli, south-eastern the Amendolara Bank until the area between Cape Trionto and Punta Alice, offshore Crotone and Cape Rizzuto as well as on the upper slope offshore Catanzaro and Punta Stilo (Carlucci *et al.*, 2009b). The more persistent nursery areas for giant red shrimp were bordered in very small areas distributed south-eastern the Amendolara Bank and offshore Crotone (Carlucci *et al.*, 2009b). A partial overlapping between nursery and spawning areas was detected in the GSA19. In fact, the highest levels of persistency for the spawning as well as nursery areas of giant red shrimp were estimated on the upper slope bottoms distributed eastern Santa Maria di Leuca, offshore Gallipoli and Punta Stilo. In particular, the upper slope from Santa Maria di Leuca to Gallipoli was characterized by the shelf-edge detritic and bathyal muds biocenoses, whilst southern the Amendolara Bank until the area between Cape Trionto and Punta Alice and offshore Crotone was characterized by bathyal muds biocenosis. The shelf break-upper slope offshore Catanzaro was characterized by the biocenosis of the terrigenous mud and shelf-edge detritic. The upper slope north-eastern Punta Stilo was characterized by the terrigenous mud and bathyal muds.

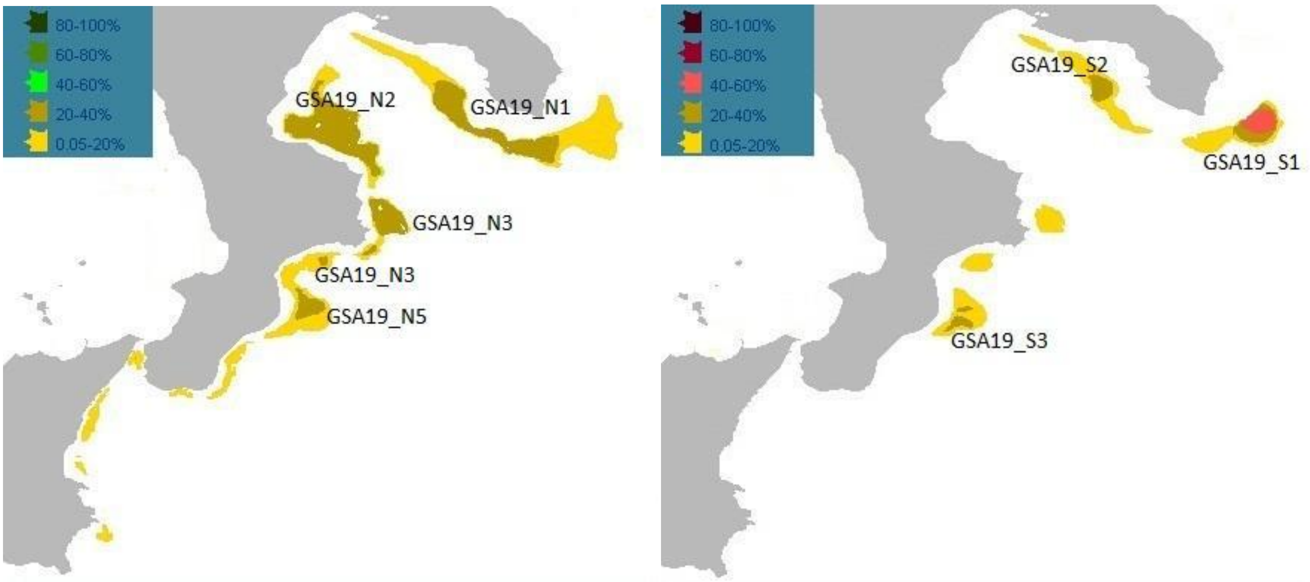


Fig. 5.2.14.6.1.2.1. Giant red shrimp in GSA 19. Position of persistent nursery (left) and spawning areas (right).

5.2.14.6.1.3 Trends in abundance and biomass

Fishery independent information regarding the state of the giant red shrimp in the GSA19 was obtained from the international survey MEDITS. Table 5.2.14.6.1.3.1 and Figure 5.2.14.6.1.3.1 displays the estimated trend of *A. foliacea* abundance and biomass standardized to the surface unit in the GSA19. Indices from MEDITS trawl-surveys show a fluctuating pattern with some evident peaks: in 2003 and 2013 for the density index and in 2003-2005 and 2013 for the biomass index.

Table. 5.2.14.6.1.3.1. Giant red shrimp in GSA 19. Abundance and biomass indices (± standard deviation).

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
N/km^2	73.9	142.3	117.3	99.4	45.6	162.0	333.9	234.6	361.3	1089.1
st. dev.	26.3	51.5	39.8	49.9	12.3	111.9	109.5	88.1	156.1	244.2
kg/km^2	0.9	1.4	1.4	0.6	0.5	1.1	2.5	1.9	3.8	8.2
st. dev.	0.3	0.5	0.5	0.2	0.1	0.6	0.7	0.6	1.5	1.6

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
N/km^2	438.0	192.8	20.7	441.3	152.4	140.6	108.2	432.1	815.1	275.7
st. dev.	94.8	33.4	9.0	175.8	48.4	62.4	36.2	124.1	235.8	87.9
kg/km^2	7.8	3.7	0.4	3.5	1.7	1.3	1.4	4.4	9.6	3.7
st. dev.	2.0	0.7	0.2	1.2	0.6	0.5	0.6	0.9	2.6	1.0

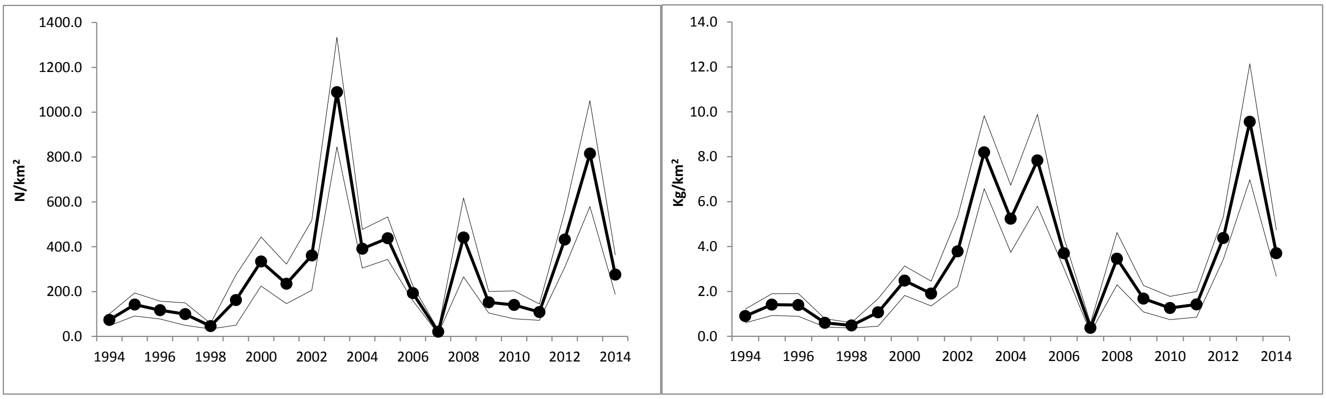


Fig. 5.2.14.6.1.3.1. Giant red shrimp in GSA 19. Abundance (left) and biomass (right) MEDITS indices (± standard deviation).

5.2.14.6.1.4 Trends in abundance by length or age

The following figures display the abundance indices by length of the giant red shrimp in GSA 19 for the period 1994-2014 (MEDITS data).

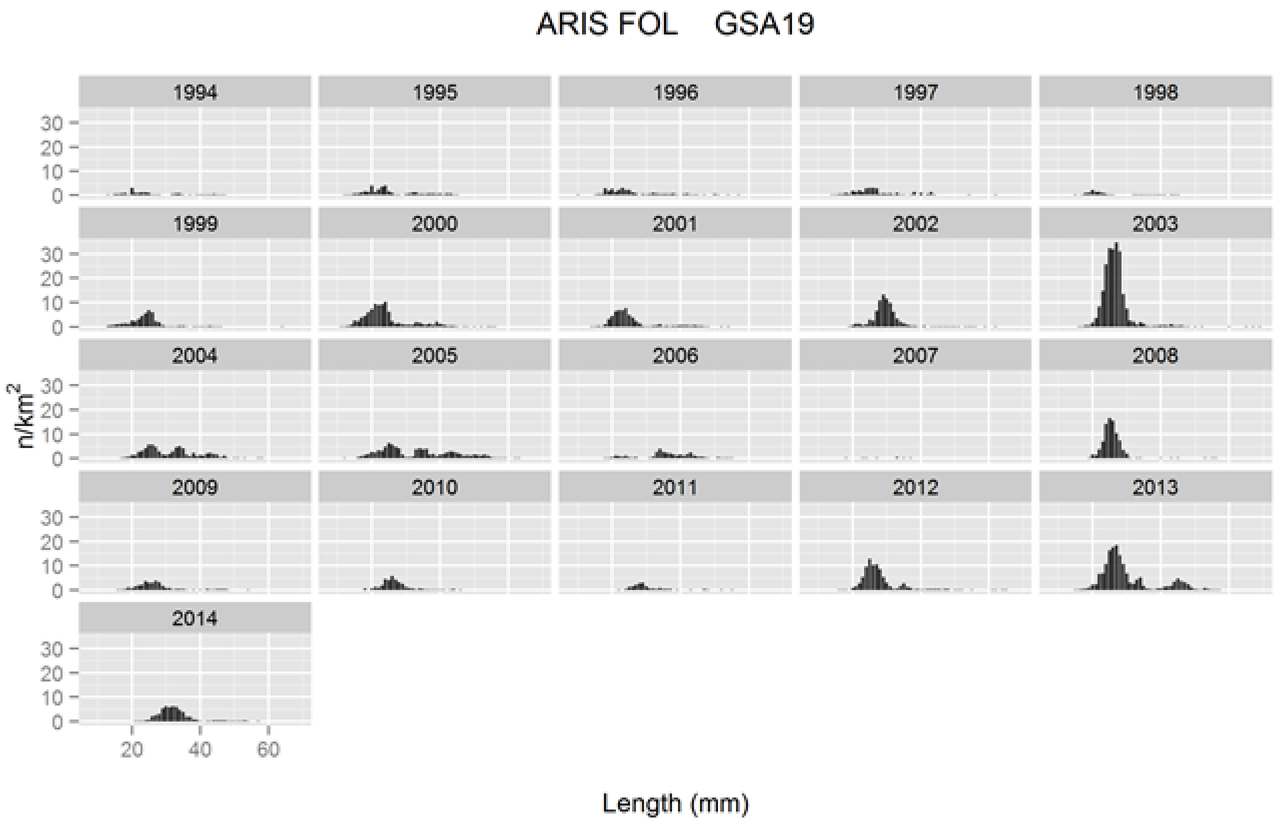


Fig. 5.2.14.6.1.4.1. Giant red shrimp in GSA 19. Stratified abundance indices by size, 1994-2014.

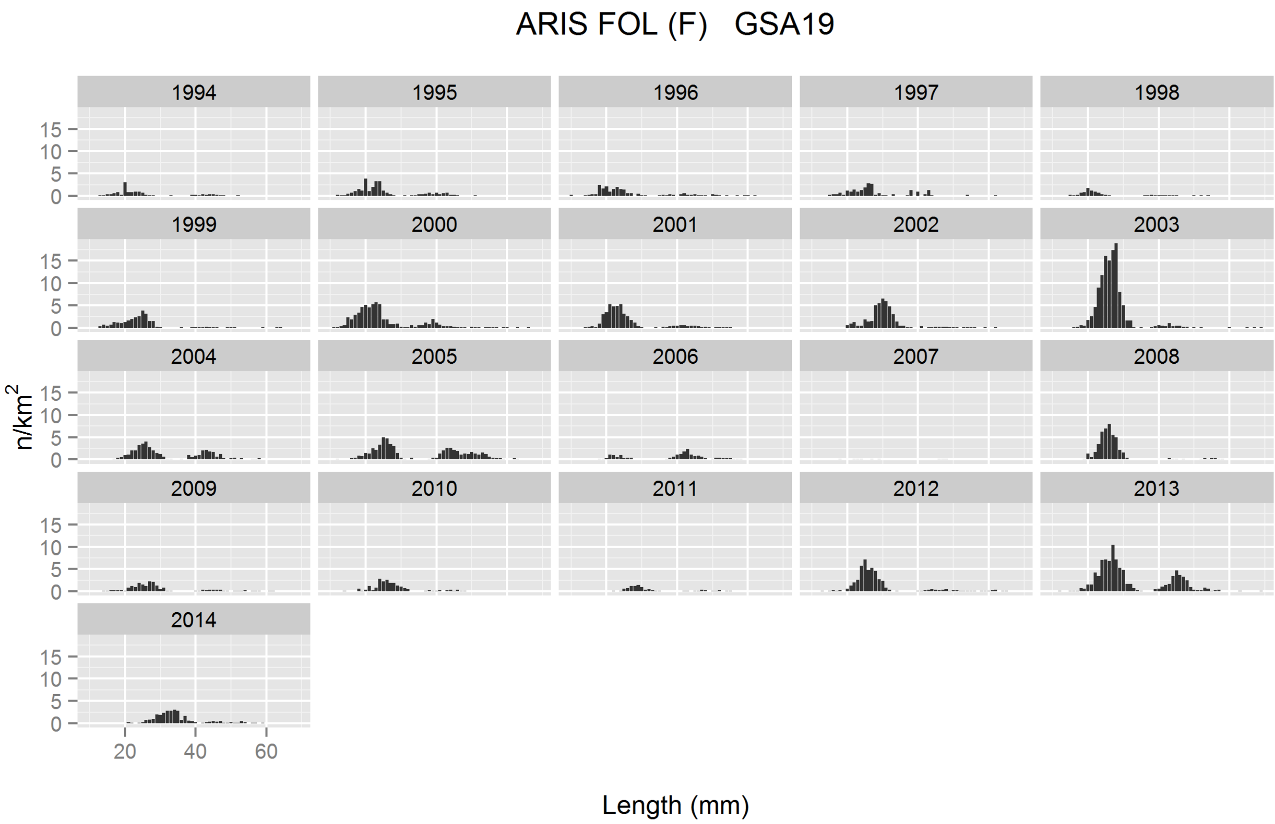


Fig. 5.2.14.6.1.4.2. Giant red shrimp in GSA 19. Stratified abundance indices by size, 1994-2014 (Females).

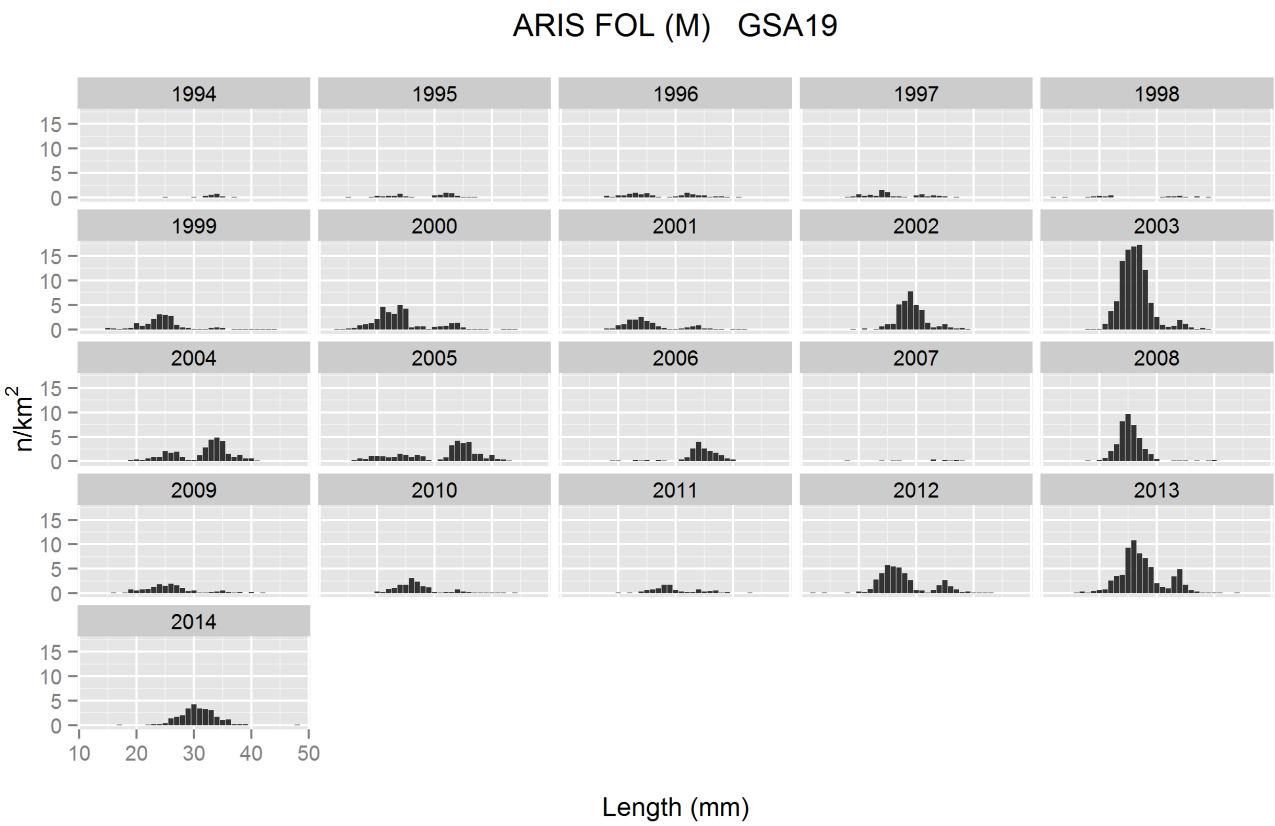


Fig. 5.2.14.6.1.4.3. Giant red shrimp in GSA 19. Stratified abundance indices by size, 1994-2014 (Males).

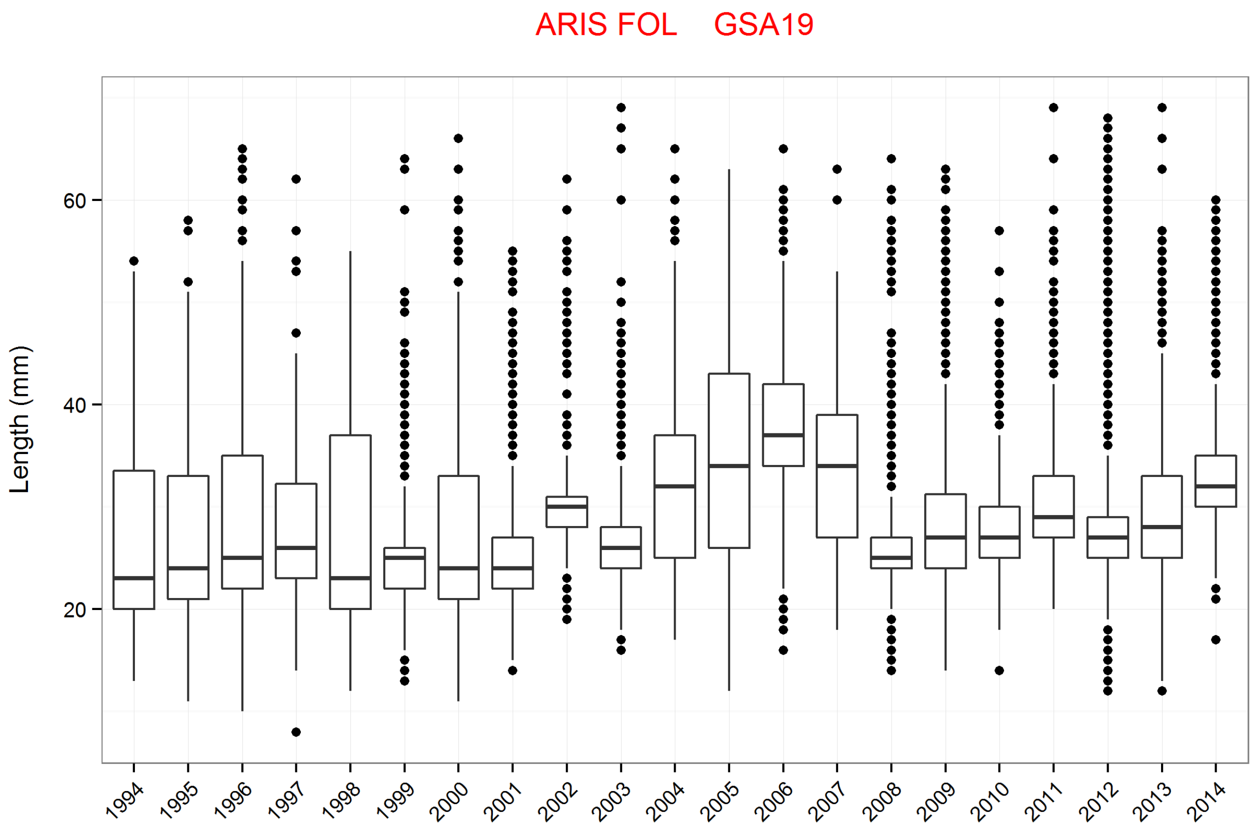


Fig. 5.2.14.6.1.4.4. Giant red shrimp in GSA 19. Demographic characteristics for the period 1994-2014.

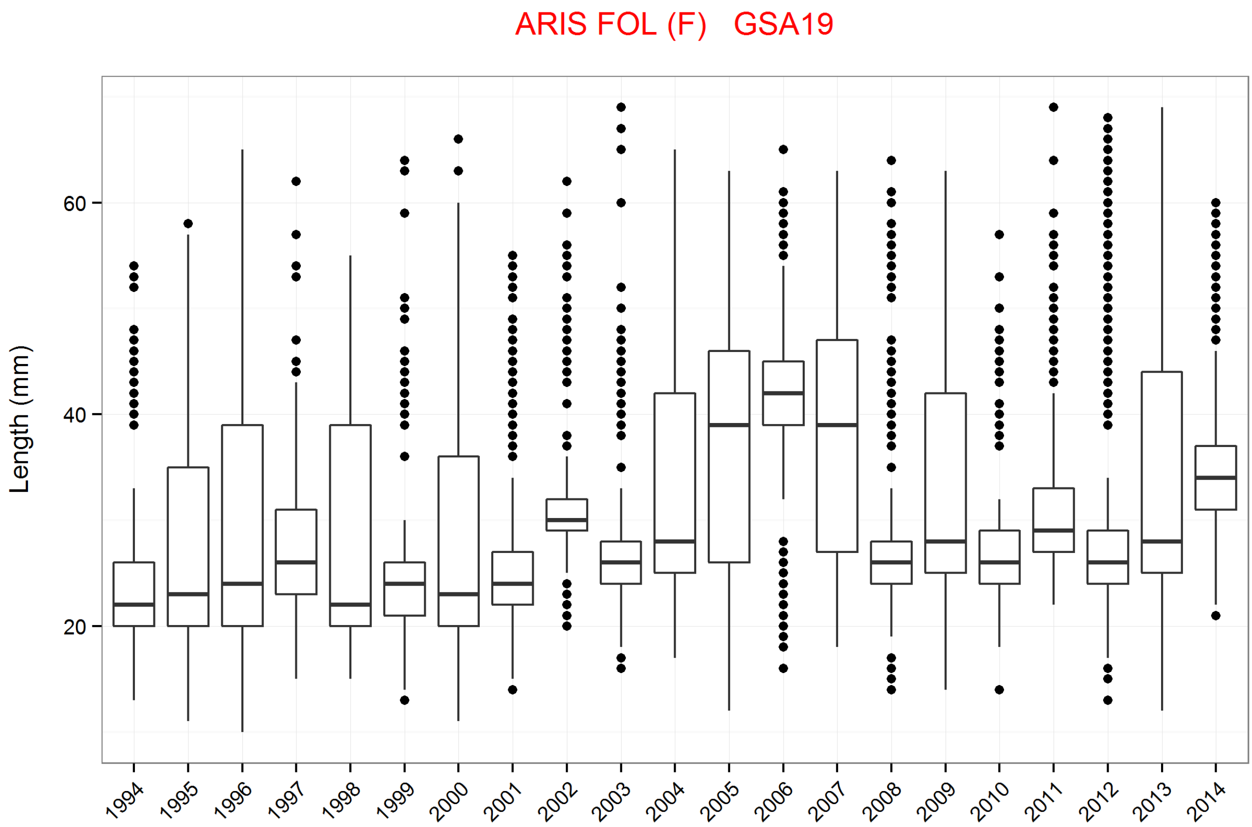


Fig. 5.2.14.6.1.4.5. Giant red shrimp in GSA 19. Demographic characteristics for the period 1994-2014.

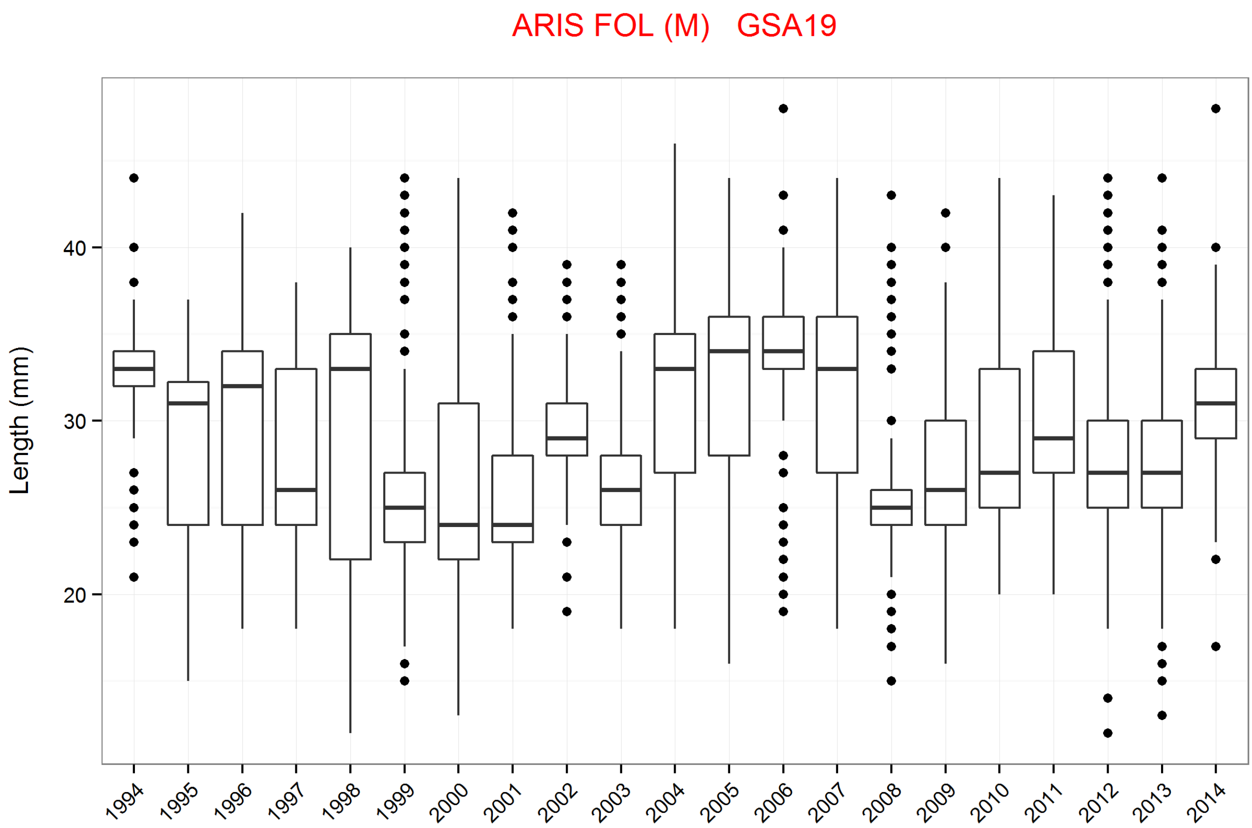


Fig. 5.2.14.6.1.4.6. Giant red shrimp in GSA 19. Demographic characteristics for the period 1994-2014.

5.2.14.7 Stock Assessment

5.2.14.7.1 Methods

The last assessment of the giant red shrimp in GSA 19 has been performed during the GFCM –SAC meeting in January 2014. In the last 2015 data call, demographic data of the commercial catches from 2008 to 2014 have been provided for the EWG-15-16; the time series from 2008 to 2014 has been considered covering the mean life span of the species, allowing to assess the stock using XSA method. The age distributions from age class 0 to 4+ have been used.

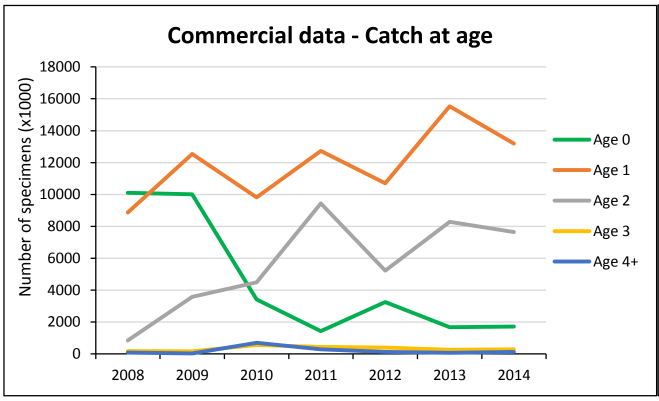
5.2.14.7.2 Input data

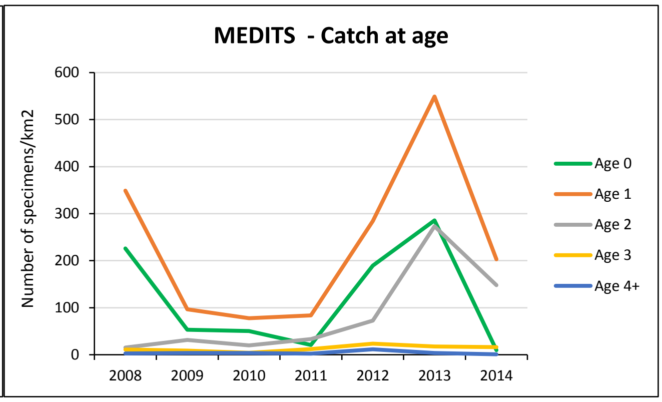
For the assessment of the giant red shrimp stock in the GSA 19, the DCF official data on the length structure has been splitted in males and females length distributions by means of a sex ratio vector by length; the age distributions by sex have been estimated using the age slicing method applying LFDA software and, then, the resulting distributions were summed up. The number of individuals by age was SOP corrected [SOP = Landings / Σa (total catch numbers at age a x catch weight-at-age a)] before performing any analysis.

Table 5.2.14.7.2.1. Giant red shrimp in GSA 19. SOP correction applyied to the age distributions by year.

	2008	2009	2010	2011	2012	2013	2014
SOP	0.927	1.121	0.973	0.968	1.079	1.057	0.978

The DCF official landing data of commercial catch have been used. A sex combined analysis was carried out. The maturity at age has been estimated using the maturity at length transformed to ages by slicing procedure. The natural mortality has been calculated using PRODBIOM (Abella, 1998). The survey indices from MEDITS data from 2008 to 2014 have been used for the tuning.
The age distributions for MEDITS and commercial catches are showed in Figure 5.2.14.7.2.1:





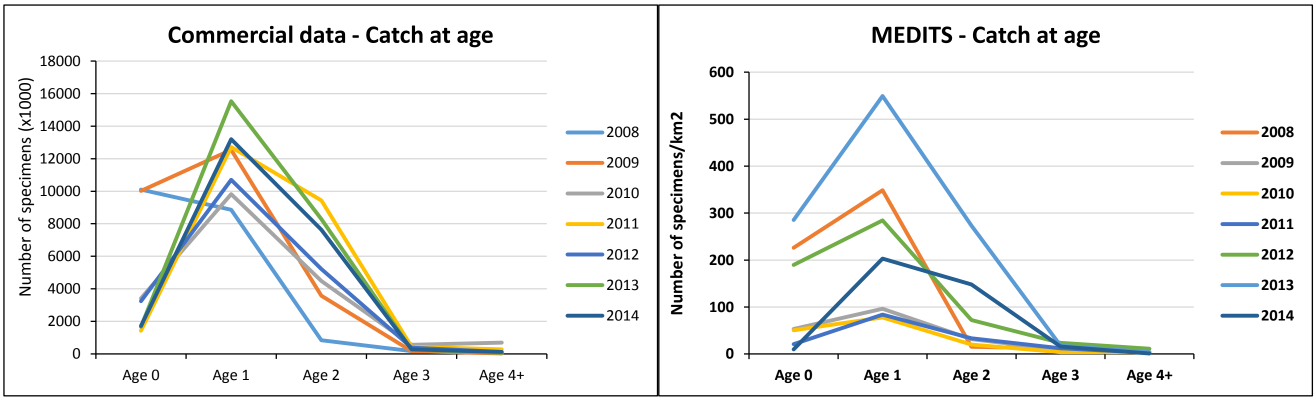


Fig. 5.2.14.7.2.1. Giant red shrimp in GSA 19. Commercial catch in numbers by age and year used in the XSA.

Other inputs are reported in the tables below:

Table 5.2.14.7.2.2. Giant red shrimp in GSA 19. Catch in numbers by age and year used in the XSA.

Catch in numbers (thousands)	age 0	age 1	age 2	age 3	age 4+
2008	10100.0	8859.8	836.0	168.0	72.5
2009	10015.1	12544.5	3575.3	164.8	24.8
2010	3417.5	9821.9	4484.2	559.3	693.9
2011	1429.8	12722.2	9440.2	433.0	281.0
2012	3242.2	10708.6	5220.0	388.8	118.9
2013	1666.5	15533.5	8287.7	260.6	59.6
2014	1711.4	13192.3	7637.2	278.6	114.3

Table 5.2.14.7.2.3. Giant red shrimp in GSA 19. Weights at age used in the XSA (used for the stock and the catch).

Weight at age (kg)	age 0	age 1	age 2	age 3	age 4+
2008	0.005	0.007	0.017	0.023	0.027
2009	0.006	0.010	0.013	0.033	0.023
2010	0.007	0.013	0.021	0.041	0.058
2011	0.007	0.014	0.016	0.029	0.024
2012	0.006	0.013	0.016	0.040	0.056
2013	0.006	0.013	0.015	0.022	0.038
2014	0.007	0.013	0.017	0.015	0.023

Table 5.2.14.7.2.4. Giant red shrimp in GSA 19. Indices from MEDITS survey used in the XSA.

Survey indices (n/km^2)	age 0	age 1	age 2	age 3	age 4+
2008	225.9	348.9	15.3	11.0	2.9
2009	53.0	96.3	31.3	8.9	3.6
2010	50.5	77.6	19.9	3.9	3.6
2011	20.9	83.6	33.2	11.9	2.1
2012	189.5	284.3	72.4	23.6	11.3
2013	285.5	549.1	273.2	17.7	3.7
2014	9.6	203.0	147.8	16.0	0.9

Table 5.2.14.7.2.5. Giant red shrimp in GSA 19. Proportion of matures at age used in the XSA.

Maturity					
Year	age 0	age 1	age 2	Age 3	Age 4+
2008	0	0.451	0.999	1	1
2009	0	0.451	0.999	1	1
2010	0	0.451	0.999	1	1
2011	0	0.451	0.999	1	1
2012	0	0.451	0.999	1	1
2013	0	0.451	0.999	1	1
2014	0	0.451	0.999	1	1

Table 5.2.14.7.2.6. Giant red shrimp in GSA 19. Natural mortality at age used in the XSA.

Natural mortality				
age 0	age 1	age 2	age 3	Age 4+
1.21	0.63	0.44	0.37	0.29

Table 5.2.14.7.2.7. Giant red shrimp in GSA 19. Growth parameters and length-weight relationship coefficient used in PRODBIOM.

Growth parameters		
	Female	Male
CLinf	73	46
K	0.438	0.500
t_0	-0.1	-0.1
a	0.0013	0.0011
b	2.65	2.73

5.2.14.7.3 Results

XSA was run setting shrinkage at 1.5, 2.0, 2.5 and 3.0. As showed by Fig. 5.2.14.7.3.1, the four different settings produced similar estimates of F, recruitment and SSB.

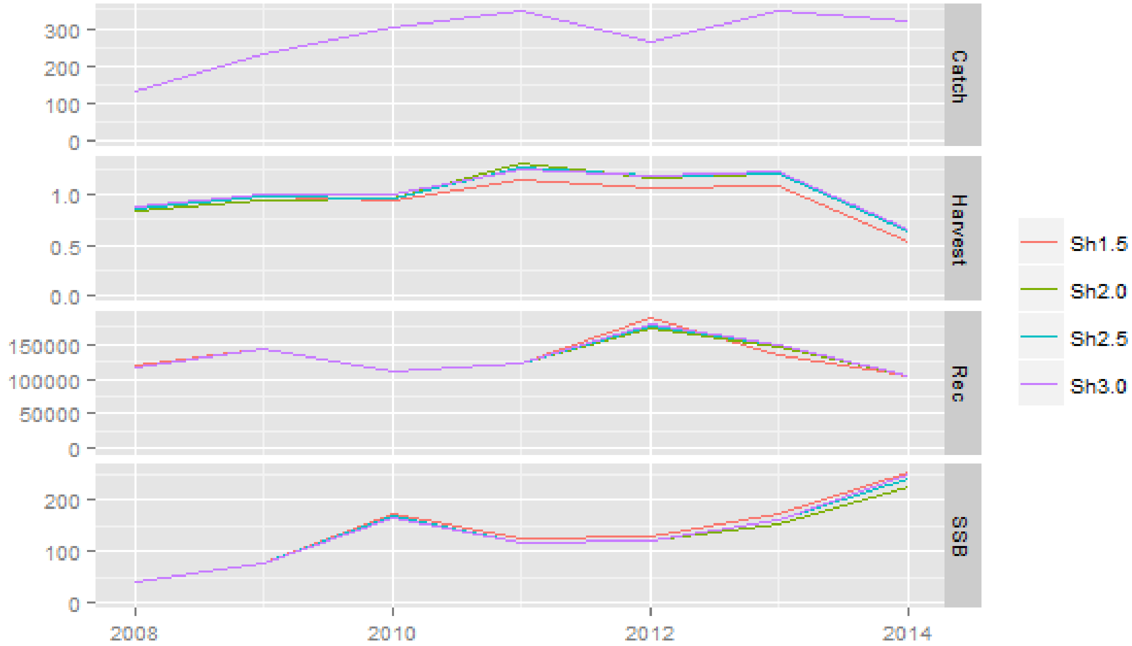


Fig. 5.2.14.7.3.1. Giant red shrimp in GSA 19. XSA outputs for different shrinkage scenario and log residuals for the tuning fleet.

Model with 2.0 shrinkage was adopted as final model based on the analysis of residual distributions (Fig. 5.2.14.7.3.2). Residuals from tuning fleets (MEDITS) per age and year were relatively low, ranging from -3.046 to 2.809 (Table 5.2.14.7.3.1.), and did not show any trend with time.
Moreover a retrospective analysis was conducted on recruitment, mean F and SSB (Figure 5.2.14.7.3.3) to ensure the robustness of the final estimates. The retrospective series indicate good agreement between years in the assessment results for F, with no systematic bias. More differences are observed for SSB and recruitment.

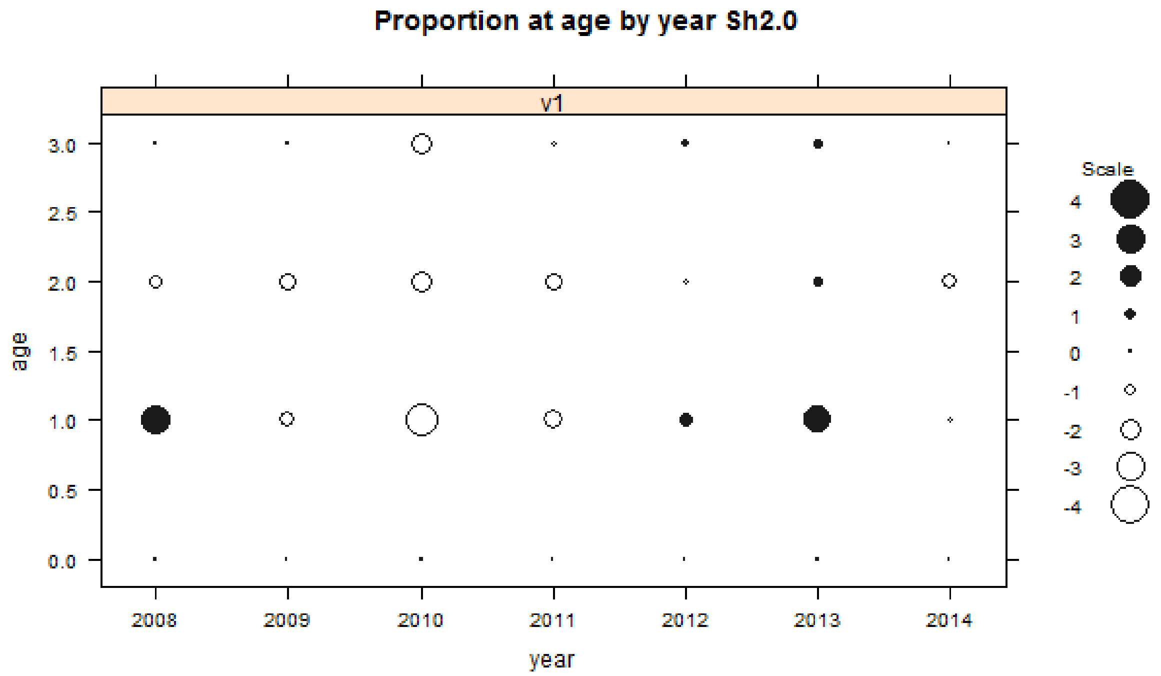


Fig. 5.2.14.7.3.2. Giant red shrimp in GSA 19. Residuals at age obtained with shrinkage set at 2.0.

Tab. 5.2.14.7.3.1. Giant red shrimp in GSA 19. Minimum, maximum and average values of the residuals at age for each different shrinkage scenario.

Shrinkage	Min	Max	Average
1.5	-5.03442	2.084454	1.86052
2.0	-3.04624	2.809417	0.27684
2.5	-3.32482	2717004	0.98130
3.0	-3.31361	2.746725	0.95426

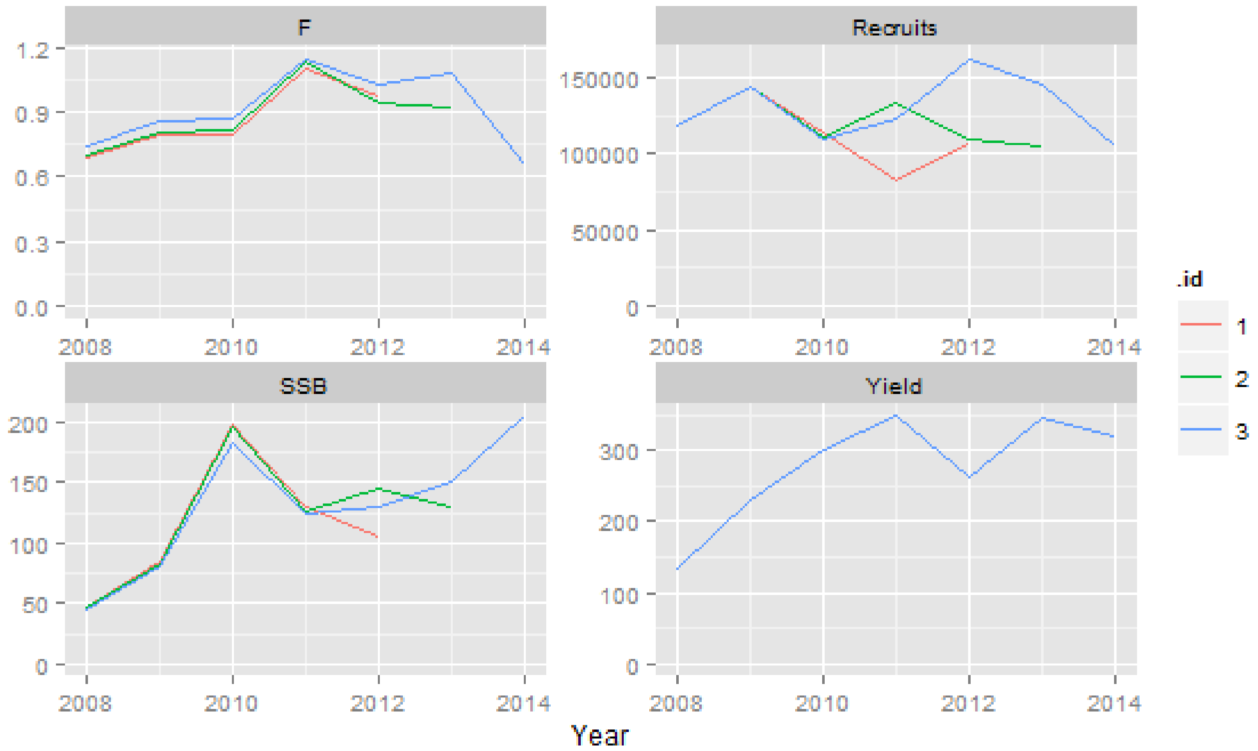


Fig. 5.2.14.7.3.3. Giant red shrimp in GSA 19. Retrospective analysis with shrinkage set at 2.0.

Based on these simulation analyses, the inputs reported in Table 5.2.14.7.3.2. were selected to run the final XSA.

Tab. 5.2.14.7.3.2. Giant red shrimp in GSA 19. Inputs selected to run the final XSA.

fse	rage	qage	Shk.n	Shk.f	Shk.yrs	Shk.ages
1.0	1.0	1.0	true	true	5.0	2.0

XSA main outputs (Fig. 5.2.14.7.3.4) showed an increase of fishing mortality in the period 2008-2011; then, high stable values were oserved till 2013. In the last year, an evident decrease was observed. SSB showed an increasing trend reaching the highest value of the time series in 2014. Recruitment was characterized by a fluctuating trend, with two main peaks in 2009 and 2012. XSA stock summary results are reported in Table 5.2.14.7.3.3.

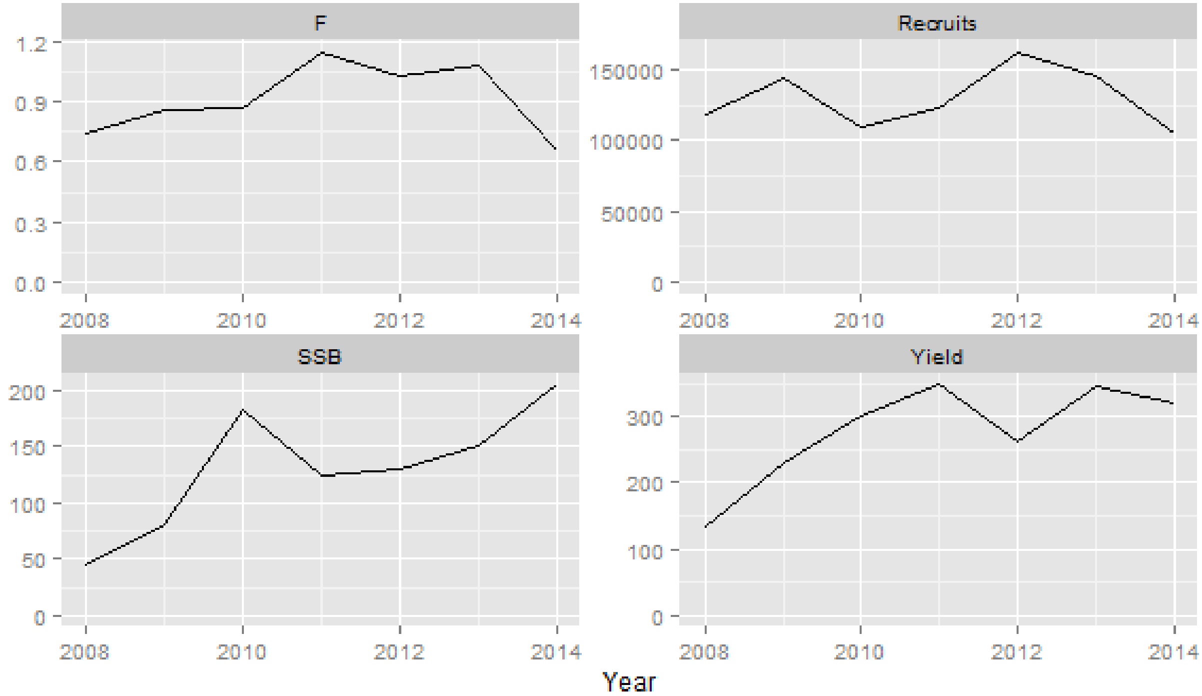


Fig. 5.2.14.7.3.4. Giant red shrimp in GSA 19. XSA summary results. SSB and catch are in tons, recruitment in thousands of individuals.

Tab. 5.2.14.7.3.3. Giant red shrimp in GSA19. XSA stock summary results.

SSB	2008	2009	2010	2011	2012	2013	2014
Tons	44.4	80.7	183.3	124.4	129.8	150.1	205.0

REC	2008	2009	2010	2011	2012	2013	2014
(x1000)	118220	143577	109762	122234	162133	145182	105456

F by age	2008	2009	2010	2011	2012	2013	2014
0	0.17	0.14	0.06	0.02	0.04	0.02	0.03
1	0.73	0.86	0.44	0.83	0.53	0.61	0.55
2	1.16	1.38	1.77	2.52	2.33	2.51	1.21
3	0.90	1.05	1.18	1.21	1.23	1.18	0.84
4+	0.90	1.05	1.18	1.21	1.23	1.18	0.84

Fbar	2008	2009	2010	2011	2012	2013	2014
(0-3)	0.74	0.86	0.86	1.15	1.03	1.08	0.66

The XSA diagnostics are reported below:

FLR XSA Diagnostics 2015-12-17 09:13:21
CPUE data from indices
Catch data for 7 years 2008 to 2014 Ages 0 to 4+

fleet	first age	last age	first year	last year	alpha	beta
Medits	0	3	2008	2014	<NA>	<NA>

Time series weights:

Tapered time weighting applied
Power = 3 over 20 years

Catchability analysis:

Catchability independent of size for ages > 1

Catchability independent of size for ages > 1

Terminal population estimation:

Survivor estimates shrunk towards the mean F
of the final 5 years of the 2 oldest ages.

S.E. of the mean to which the estimates shrunk = 2.0

Minimum standard error for population
estimates derived from each fleet = 0.3

prior weighing not applied

weights
year

age	2008	2009	2010	2011	2012	2013	2014
all	0.921	0.954	0.976	0.99	0.997	1	1

Fishing mortalities
year

age	2008	2009	2010	2011	2012	2013	2014
0	0.171	0.137	0.059	0.022	0.035	0.021	0.031
1	0.746	0.872	0.449	0.836	0.531	0.564	0.546
2	1.253	1.442	1.895	2.649	2.467	2.596	1.010
3	1.171	1.344	1.415	1.707	1.671	1.649	0.983
4	1.171	1.344	1.415	1.707	1.671	1.649	0.983

XSA population number (Thousand)
Age

year	0	1	2	3	4+
2008	117198	23093	1458	293	121
2009	142741	29531	5836	268	39
2010	109127	37218	6576	889	1052
2011	121699	30772	12658	637	391
2012	171028	35619	7108	576	167
2013	146597	49383	11160	388	84
2014	103499	42937	14970	536	212

Estimated population abundance at 1st Jan 2015
age

year	0	1	2	3	4+
2015	0	29895	13199	2766	133

Fleet: Medits

Log catchability residuals.

Year							
age	2008	2009	2010	2011	2012	2013	2014
0	0.081	-0.032	0.022	-0.045	-0.014	0.039	-0.046
1	2.809	-1.222	-3.046	-1.784	1.053	2.514	-0.245
2	-1.034	-1.591	-1.882	-1.566	-0.320	0.636	-1.245
3	0.148	0.130	-1.858	-0.224	0.541	0.632	-0.201
Regression statistics							
Ages with q dependent on year class strength							
"0.217976657338042" "1.72729188736119" "10.6746235620006" "0.0844452735037641"							
Terminal year survivor and F summaries:							
,Age 0 Year class 2014							
	scaledWts	survivors	yrcls				
Medits	0.400	24294	2014				
fshk	0.009	15549	2014				
nshk	0.591	34762	2014				
,Age 1 Year class 2013							
	scaledWts	survivors	yrcls				
Medits	0.507	11491	2013				
fshk	0.493	10001	2013				
,Age 2 Year class 2012							
	scaledWts	survivors	yrcls				
Medits	0.396	1011	2012				
fshk	0.604	696	2012				
,Age 3 Year class 2011							
	scaledWts	survivors	yrcls				
Medits	0.645	113	2011				
fshk	0.355	191	2011				

5.2.14.8 Reference points

5.2.14.8.1 Methods

The yield per recruit (YpR) analysis was run using XSA method. The analysis was performed to estimate $F_{0.1}$ as limit equilibrium YPR-based reference point for the stock.

5.2.14.8.2 Input data

The input parameters were the same used for the XSA stock assessment and its results.

5.2.14.8.3 Results

YpR output curve is illustrated in the Figure 5.2.14.8.3.1, while $F_{0.1}$ and F_{bar} are compared in Figure 5.2.14.8.3.2. $F_{0.1}$ estimated by the model was 0.29.

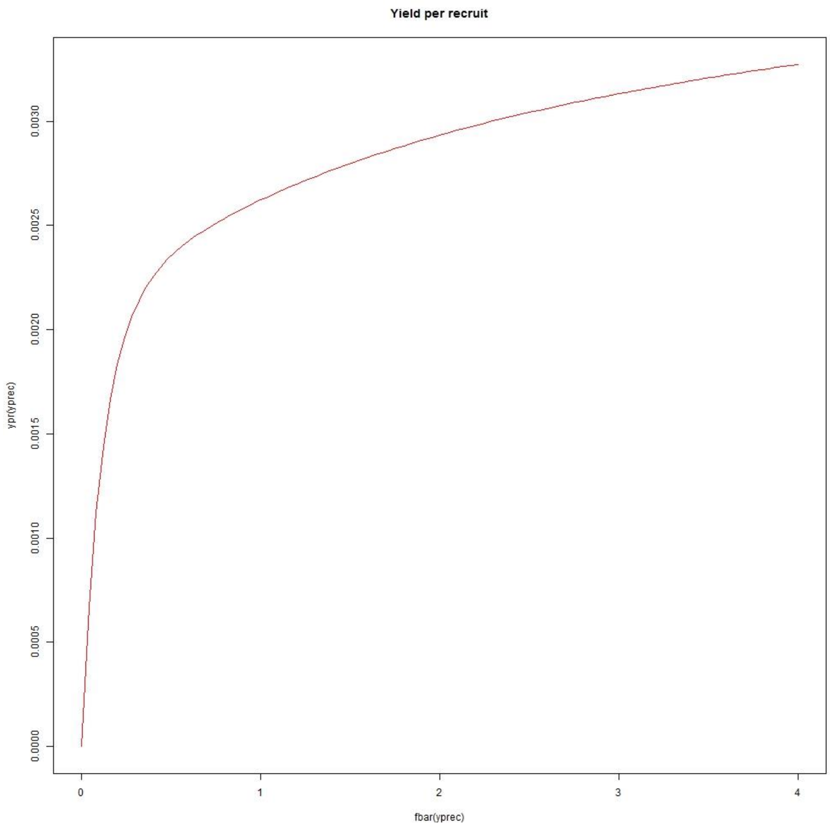


Fig. 5.2.14.8.3.1. Giant red shrimp in GSA 19. Yield per Recruit curve.

As shown in figure 5.2.14.8.3.2, F_{bar} remained over the $F_{0.1}$ reference value for the whole analysed time series.

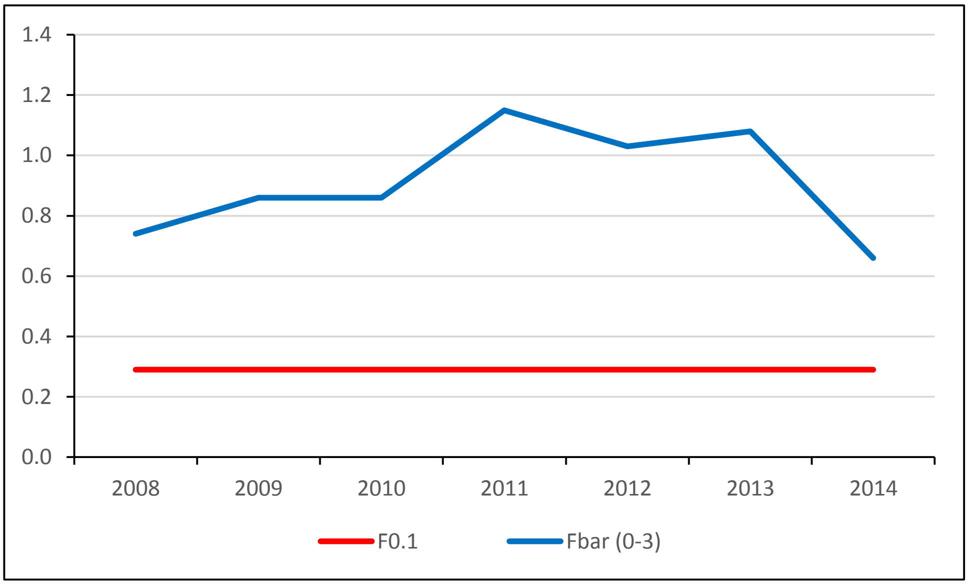


Fig. 5.2.14.8.3.2. Giant red shrimp in GSA 19. Trend of F_{bar} obtained by means of XSA and comparison with $F_{0.1}$.

5.2.14.9 Data quality

Demographic structures of OTB landing and discard were available for the period 2008-2014.

5.2.14.10 Short term predictions 2016-2018

5.2.14.10.1 Method

A deterministic short term forecast for the period 2015 to 2017 was performed using the FLR routines provided by JRC and based on the results of the XSA stock assessments performed during EWG14-19 for the years 2008–2014.

5.2.14.10.2 Input parameters

The input parameters were the same used for the XSA stock assessment computations as well XSA results. Computations were performed for different scenarios, zero catch, F at reference point, Fstatus quo and a series of multipliers of Fstq were performed. Fstq=0.901 has been estimated as the geometric mean of the fishing mortality of last three years (2012-2014) estimated with FLR.

5.2.14.10.3 Results

A short term projection (Table 5.2.14.10.3.1), assuming an Fstq of 0.901 in 2015 and a recruitment of 135399 thousands individuals, shows that:

- Fishing at the Fstq (0.901) generates a decrease of the catch of about 1% from 2014 to 2016 and an increase of about 2% of the spawning stock biomass 2016 to 2017.

- Fishing at $F_{0.1}$ (0.29) generates a decrease of the catch of about 56% from 2014 to 2016 and an increase of the spawning stock biomass of about 50% from 2016 to 2017.

Table 5.2.14.10.3.1. Giant red shrimp in GSA 19. Short term forecast in different F scenarios. Basis: F(2015) = mean(F_{bar} 0-3 2012-2014)= 0.901; R(2015) = geometric mean of the recruitment of the last 3 years; R = 135399 (thousands); Catch (2014)= 320 t.

Rationale	Ffactor	Fbar	Catch 2016	Catch 2017	SSB 2017	Change SSB 2016-2017(%)	Change Catch 2014-2016(%)
Zero catch	0	0	0	0	558.2	94.9	-100
High long term yield F(0.1)	0.33	0.29	140.7	207.8	355.1	50.2	-56.0
Status quo	1	0.90	324.5	346.6	168.2	2.4	1.4
Different scenarios	0.1	0.09	48.6	83.3	482.6	79.0	-84.8
	0.2	0.18	92.2	147.5	419.6	65.1	-71.2
	0.3	0.27	131.4	197.2	366.9	53.0	-58.9
	0.4	0.36	166.9	235.9	322.7	42.4	-47.8
	0.5	0.45	199.2	266.1	285.4	33.2	-37.8
	0.6	0.54	228.6	290.0	253.9	25.2	-28.6
	0.7	0.63	255.5	308.9	227.1	18.3	-20.2
	0.8	0.72	280.3	324.1	204.4	12.2	-12.4
	0.9	0.81	303.2	336.5	184.9	6.9	-5.2

	1.1	0.99	344.2	355.0	153.7	-1.6	7.6
	1.2	1.08	362.6	362.2	141.2	-5.0	13.3
	1.3	1.17	379.9	368.3	130.4	-8.0	18.7
	1.4	1.26	396.1	373.6	120.9	-10.5	23.8
	1.5	1.35	411.3	378.3	112.6	-12.7	28.5
	1.6	1.44	425.6	382.5	105.1	-14.6	33.0
	1.7	1.53	439.1	386.3	98.6	-16.1	37.2
	1.8	1.62	451.9	389.8	92.8	-17.5	41.2
	1.9	1.71	464.1	393.1	87.6	-18.6	45.0
	2.0	1.80	475.6	396.1	82.9	-19.6	48.6

5.2.14.11 Medium term predictions

5.2.14.11.1 Method

The medium term projections were not conducted because no meaningful stock-recruitment relationship was found.

5.2.14.12 Stock advice

STECF-EWG 15-16 proposes $F_{0.1}$=0.29 as limit management reference point consistent with high long term yield and lower risk of stock collapse.

SSB showed an increasing trend in the analysed period, while recruitment fluctuated. As concerns F, an evident increasing trend is observed in the period 2008-2010. High values were found from 2011 to 2013, while in 2014 a decrease was observed. According to the F estimates obtained using landing and discard data with XSA, Fcurr (0.90), estimated as geometric mean of the last three years (2012-2014), was above the estimated reference value of $F_{0.1}$=0.29.

STECF-EWG 15-16 advises to reduce the current level of catches and/or effort of the relevant fleets in order to avoid future loss in stock productivity. Catches of giant red shrimp in 2016 in GSA 19 consistent with $F_{0.1}$ (0.29) would not exceed 140.7 tonnes.

5.2.14.13 Management Strategy Evaluation

The Management Strategy Evaluation was ran to evaluate if the MSY ranges were precautionary. The F_{MSY} ranges were derived using the formula provided by STECF 15-09.

F ranges results were F_{upper}=0.40 and F_{lower}=0.19. B_{lim} was estimated as B_{loss}=44.4 (t).

The following figure shows the results of the MSE.

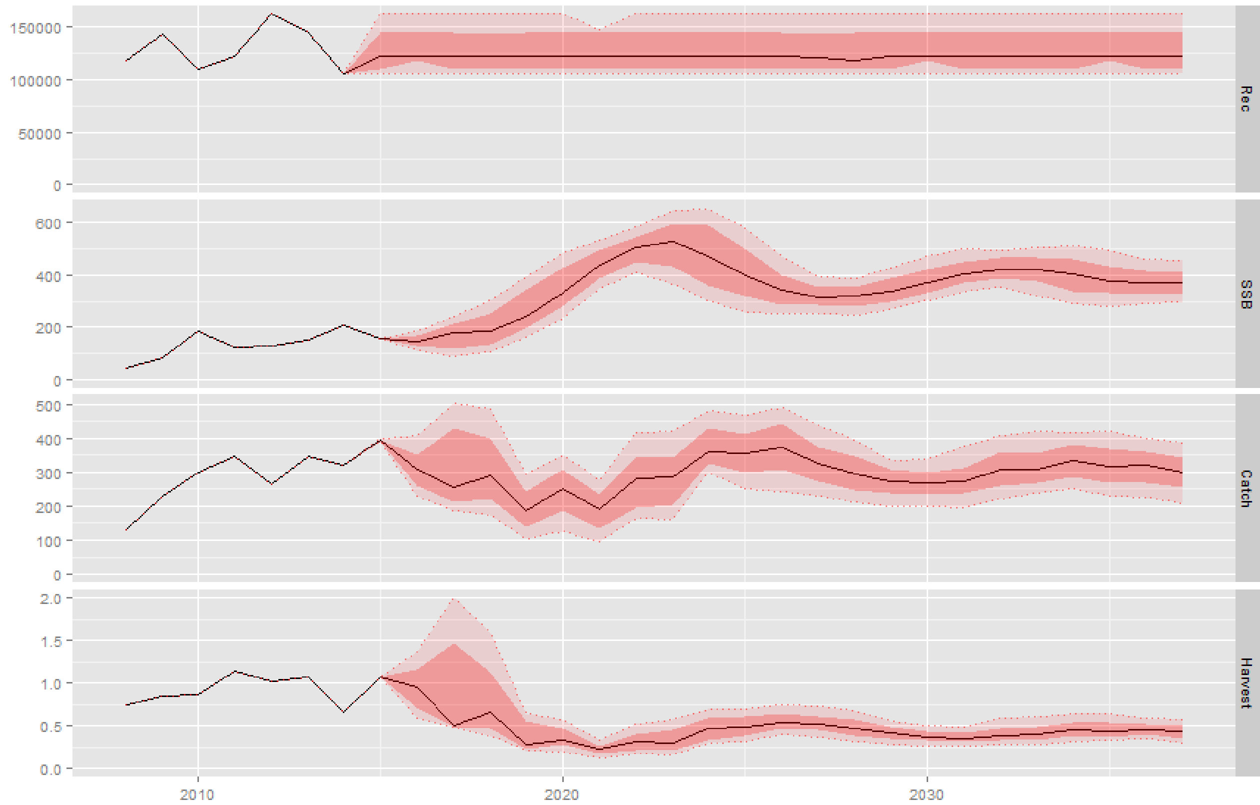


Figure 5.2.14.13.1. Giant red shrimp in the GSA 19. Management Strategy Evaluation.

Probability to fall below Blim at F = F_{upper} is equal to 0.

5.2.15 STOCK ASSESSMENT OF GIANT RED SHRIMP IN GSA 18-19

Stock Identification

STECF EWG 15-16 was asked to assess the state of giant red shrimp stocks in the Adriatic and Ionian Sea following two approaches: by single GSAs and GSAs combined. The present assessment will investigate the state of the giant red shrimp stock in GSAs 18 and 19.

Based on the available information on the geographic distribution of giant red shrimp populations in GSA 18 both in general (Figure 5.2.13.6.1.2.1) and as critical habitats in particular (Figure 5.2.13.6.1.2.2), and considering the south to north direction of the mainstream current it is unlikely that there are two separate stocks of giant red shrimp in GSA 18 and 19. Instead the population found in GSA 18 should be considered part of a larger stock distributed in both GSA 18 and GSA 19.

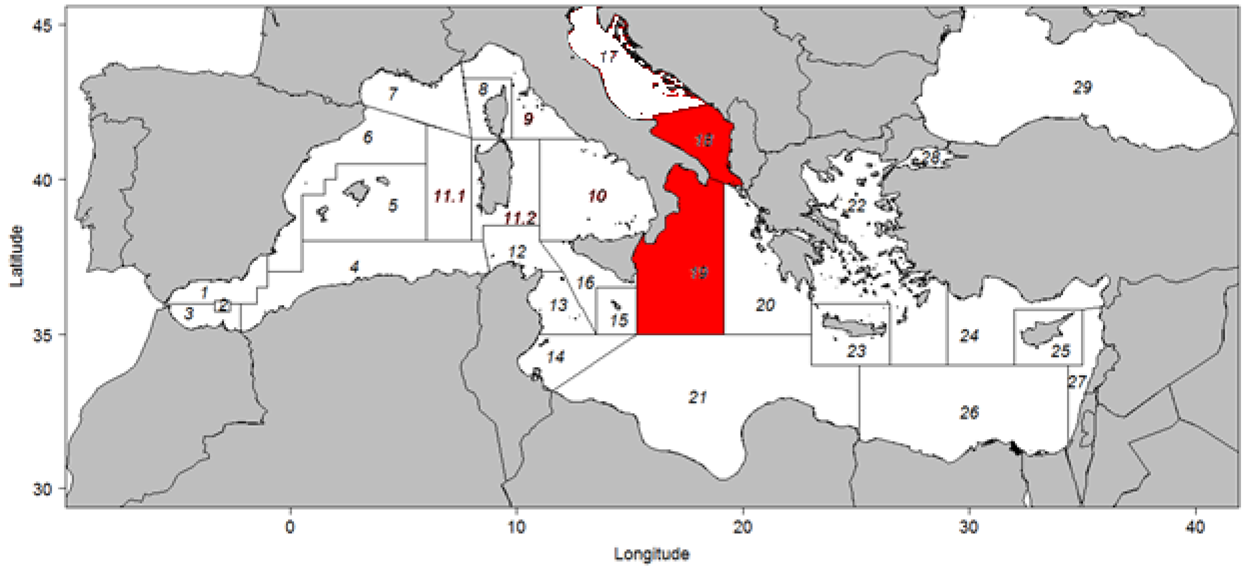


Figure 5.2.15.1.1. Geographical location of GSAs 18 and 19.

Growth

Growth parameters are those used in each GSA (see sections of GSA 18 and GSA 19 assessments).

Maturity

Maturity ogives were taken from each GSA (see sections of GSA 18 and GSA 19 assessments). Combined maturity at age were calculated as a weighted average using the stock numbers.

Natural mortality

Natural mortality was taken from each GSA (see sections of GSA 18 and GSA 19 assessments). Combined natural mortality at age were calculated as a weighted average using the stock numbers.

Fisheries

5.2.15.1.1 General description of the fisheries

Giant red shrimp is targeted mainly by bottom trawlers. See Chapters 5.2.13.5.1-5.2.14.5.1 in the Report for further details on Giant red shrimp fisheries in GSAs 18, and 19.

5.2.15.1.2 Management regulations applicable in 2015

See Chapters 5.2.13.5.2-5.2.14.5.2 in the Report for management regulations on giant red shrimp fisheries in GSAs 18 and 19.

5.2.15.1.3 Catches (by fleet if possible)

The catch is composed almost exclusively by marketed individuals. Landings and discards by fleet are described in the following sections 5.2.15.5.4 and 5.2.15.5.5.

5.2.15.1.4 Landings

Official EU DCF landings data for giant red shrimp in GSA 18 was available for the period 2003-2014 and from 2004 to 2014 in GSA 19.

Table 5.2.15.5.4.1. Giant red shrimp in GSA 18-19. Annual landings (tons) by fishery, from 2003 to 2014.

Year	Area	Gear	Fishery	Landings	Year	Area	Gear	Fishery	Landings
2003	SA 18	-1	-1	72.34254	2009	SA 18	OTB	-1	88.36389
2003	SA 18	GNS	-1	12.66418	2009	SA 19	OTB	DWSP	83.85047
2003	SA 18	OTB	-1	113.0074	2009	SA 19	OTB	MDDWSP	142.0306
2003	SA 19	OTB	-1	3.58002	2010	SA 18	OTB	-1	127.4334
2004	SA 18	OTB	MDDWSP	89.14578	2010	SA 19	OTB	MDDWSP	123.9672
2004	SA 19	GNS	DEMF	1.13101	2010	SA 19	OTB	DWSP	177.473
2004	SA 19	OTB	-1	61.84126	2011	SA 18	OTB	-1	75.21851
2005	SA 18	OTB	MDDWSP	72.08849	2011	SA 19	OTB	DWSP	232.3134
2005	SA 19	OTB	MDDWSP	54.73064	2011	SA 19	OTB	MDDWSP	114.4891
2006	SA 18	-1	-1	3.11611	2012	SA 18	OTB	MDDWSP	15.01143
2006	SA 18	OTB	MDDWSP	165.6246	2012	SA 19	GTR	DEMSP	1.40081
2006	SA 19	OTB	DWSP	36.6585	2012	SA 19	OTB	MDDWSP	96.24149
2006	SA 19	OTB	MDDWSP	199.8074	2012	SA 19	OTB	DWSP	164.7498
2007	SA 18	OTB	MDDWSP	114.8724	2013	SA 18	OTB	MDDWSP	14.50999
2007	SA 19	OTB	DWSP	97.0813	2013	SA 19	GTR	DEMSP	2.31689
2007	SA 19	OTB	MDDWSP	101.5089	2013	SA 19	OTB	DWSP	233.7734
2008	SA 18	OTB	MDDWSP	37.11453	2013	SA 19	OTB	MDDWSP	112.8405
2008	SA 18	OTB	DWSP	59.57111	2014	SA 18	OTB	MDDWSP	8.08527
2008	SA 19	OTB	-1	132.5847	2014	SA 19	OTB	DWSP	250.6308
					2014	SA 19	OTB	MDDWSP	69.39927

No landings of giant red shrimp are reported from Montenegro or Albania in the FAO FishStat database. For more details on landings and age-structure of landings, please see sections 5.2.13.5.4-5.2.14.5.4 in this report.

5.2.15.1.5 Discards

Discards data were reported to STECF EWG 15-16 through the DCF.
Although discards were really negligible they were included in the stock assessment. For more details on discards please see sections 5.2.13.5.5-5.2.14.5.5 in this report

Table 5.2.15.5.5.1. Giant red shrimp in GSA 18-19. Annual discards (tons) by fishery, from 2009 to 2014.

Year	Area	Gear	Fishery	Discards
2009	SA 18	OTB	-1	0.185409
2009	SA 19	OTB	DWSP	5.262481
2009	SA 19	OTB	MDDWSP	0
2010	SA 18	OTB	-1	0
2010	SA 18	OTB	DWSP	0
2010	SA 18	OTB	MDDWSP	0
2010	SA 19	OTB	MDDWSP	0
2010	SA 19	OTB	DWSP	0
2011	SA 18	OTB	-1	0.024352
2011	SA 19	OTB	DWSP	0
2011	SA 19	OTB	MDDWSP	0
2012	SA 18	OTB	MDDWSP	0
2012	SA 19	GTR	DEMSP	0
2012	SA 19	OTB	MDDWSP	0.867555
2012	SA 19	OTB	DWSP	0.942738
2013	SA 18	OTB	MDDWSP	0
2013	SA 19	GTR	DEMSP	0
2013	SA 19	OTB	DWSP	0
2013	SA 19	OTB	MDDWSP	0
2014	SA 18	OTB	MDDWSP	0
2014	SA 19	OTB	MDDWSP	0
2014	SA 19	OTB	DWSP	0

5.2.15.1.6 Fishing effort (by fleet if possible)

Fishing effort data were reported to STECF EWG 15-16 through DCF. For more details on fishing effort, please see sections 5.2.13.5.6-5.2.14.5.6 in this report.

Scientific surveys

5.2.15.1.7 Survey #1 (MEDITS)

5.2.15.1.7.1 Methods

Based on the DCF data call, abundance and biomass indices were calculated by GSAs using the ad hoc script prepared during the STECF EWG 15-06. The data coming from MEDITS surveys are presented in sections 5.2.13.6-5.2.14.6 of this report.

5.2.15.1.7.2 Geographical distribution

Information on the spatial and temporal distribution of giant red shrimp recruits as well as of adults in GSAs 18 and 19 is presented in sections 5.2.13.6.1.2-5.2.14.6.1.2 of this report.

5.2.15.1.7.3 Trends in abundance and biomass

Giant red shrimp time series of abundance and biomass indices from MEDITS surveys are shown and described in sections 5.2.13.6.1.3-5.2.14.6.1.3 of this report.

5.2.15.1.7.4 Trends in abundance by length or age

The stratified abundance indices of giant red shrimp are shown and described in sections 5.2.13.6.1.4-5.2.14.6.1.4 of this report.

Stock Assessment

Stock assessment has been conducted using 2 methods XSA and a4a

5.2.15.1.8 Methods

Method: XSA (Extended Survival Analysis)

FLR libraries were employed in order to carry out an XSA based assessment. The giant red shrimp stock in GSAs 18-19 was assessed for the first time. XSA was carried out using as input data the period 2008-2014 both for the catch data and for the tuning file.

Method: A4A

An attempt was made to use the a4a framework developed by the Joint Research Centre to fit an assessment model for this stock. a4a is a framework that allows to compute statistical catch at age models. Its flexibility allows to fit a wide range of models to the data. Compared to XSA, a4a runs forward and allows to reach a better stability for last years estimates. As it is the first year this method was used, the results were compared to an XSA run.

5.2.15.1.9 Input data

Total catches and catch numbers at age from the single GSAs were used as input data. The R script prepared by JRC was used to create a combined stock object to be used in the assessment. Natural mortality and maturity were estimated as weighted mean by the catch numbers from the parameters used in the assessments of the single GSAs.

Table 5.2.12.7.2.1 lists the input parameters to the XSA, namely landings, catch number at age, weight at age, maturity at age, natural mortality at age and the tuning series at age.

Table 5.2.15.7.2.1. Giant red shrimp in GSAs 18-19. Input data to the XSA model.

Catches (t)

2008	2009	2010	2011	2012	2013	2014
228.28	319.69	428.87	422.76	277.81	361.12	328.12

Catch numbers-at-age (thousands)

Age	2008	2009	2010	2011	2012	2013	2014
0	17390.15	11150.93	4715.45	1538.43	3274.11	1702.54	1793.64
1	15254.87	15527.73	12700.38	13804.94	10936.47	15753.00	13389.24
2	1439.50	5869.11	7241.74	11048.16	5530.67	8594.94	7873.71
3	289.19	378.77	949.84	1229.76	594.30	332.54	334.91
4+	124.90	41.67	780.76	336.32	130.15	72.07	118.49

Weights-at-age in the catch and in the stock (kg)

Age	2008	2009	2010	2011	2012	2013	2014
0	0.005	0.006	0.007	0.007	0.006	0.007	0.007
1	0.007	0.010	0.013	0.014	0.013	0.013	0.013
2	0.017	0.015	0.021	0.016	0.016	0.015	0.017
3	0.023	0.027	0.035	0.024	0.033	0.022	0.015
4+	0.027	0.024	0.055	0.026	0.054	0.036	0.023

Natural mortality vectors.

Age	2008	2009	2010	2011	2012	2013	2014
0	1.19	1.20	1.20	1.20	1.21	1.21	1.21
1	0.62	0.63	0.63	0.63	0.63	0.63	0.63
2	0.44	0.44	0.44	0.44	0.44	0.44	0.44
3	0.37	0.36	0.37	0.36	0.37	0.37	0.37
4+	0.29	0.29	0.29	0.29	0.29	0.29	0.29

Maturity vectors.

Age	2008	2009	2010	2011	2012	2013	2014
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	0.44	0.38	0.39	0.35	0.33	0.33	0.33
2	0.98	0.98	0.98	0.97	0.97	0.97	0.97
3	1.00	1.00	1.00	1.00	1.00	1.00	1.00
4+	1.00	1.00	1.00	1.00	1.00	1.00	1.00

MEDITS number (n/km^2) at age for GSA 18.

Age	2008	2009	2010	2011	2012	2013	2014
0	5.500	13.607	1.682	3.482	4.121	5.597	0.903
1	19.912	73.238	3.577	4.619	16.040	35.906	14.798
2	10.060	43.611	19.394	17.749	24.834	54.573	41.391
3	3.828	4.439	8.644	19.353	15.776	16.108	25.761
4+	7.830	2.642	2.136	2.749	1.244	0.786	1.154

MEDITS number (n/km^2) at age for GSA 19.

Age	2008	2009	2010	2011	2012	2013	2014
0	225.936	53.035	50.496	20.877	189.471	285.53	9.612
1	348.891	96.334	77.647	83.575	284.266	549.126	203.003
2	15.319	31.262	19.94	33.182	72.367	273.234	147.83
3	11.004	8.906	3.867	11.858	23.585	17.653	15.961
4+	2.915	3.61	3.55	2.115	11.345	3.667	0.936

5.2.15.1.10 Results

Method: XSA

Sensitivity analyses were conducted to assess the effect of the main parameters. Setting rage value=-1, qage=3, shk.years=5 and shk.ages=2, values ranging from 0.5 to 3 (0.5 increasing) have been tested.

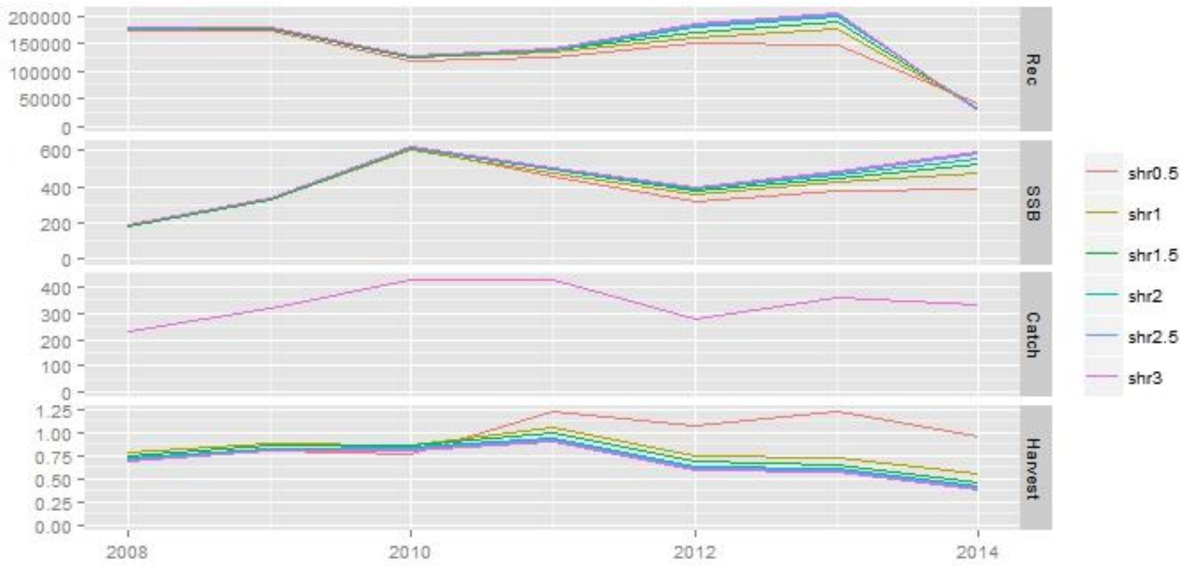


Figure 5.2.15.7.3.1. Giant red shrimp in GSA 18-19. Sensitivity on shrinkage weight.

In Table 5.2.15.7.3.1 the residuals of the models with different shrinkage values are presented.

Table 5.2.15.7.3.1. Giant red shrimp in GSA 18-19. Minimum, maximum, and average residual values of the XSA models with different shrinkage weight values for the two tuning fleets.

Shrinkage	Minimum GSA19	Maximum GSA19	Average GSA19	Minimum GSA18	Maximum GSA18	Average GSA18
0.5	-1.909	1.851	0.811	-1.685	1.512	0.603
1	-1.290	1.513	0.682	-1.631	1.579	0.417
1.5	-1.280	1.483	0.654	-1.603	1.608	0.410
2	-1.281	1.469	0.639	-1.588	1.622	0.416
2.5	-1.281	1.459	0.631	-1.580	1.630	0.420
3	-1.282	1.453	0.626	-1.575	1.635	0.423

As a result, the settings that minimized the residuals and showed the best diagnostics output also in term of retrospective analysis were used for the final assessment, and are the following:

Fbar	fse	rage	qage	shk.yrs	shk.age
0-3	1.5	-1	3	5	2

The residuals pattern of the MEDITS trawl survey is shown in Figure 5.2.15.7.3.2.

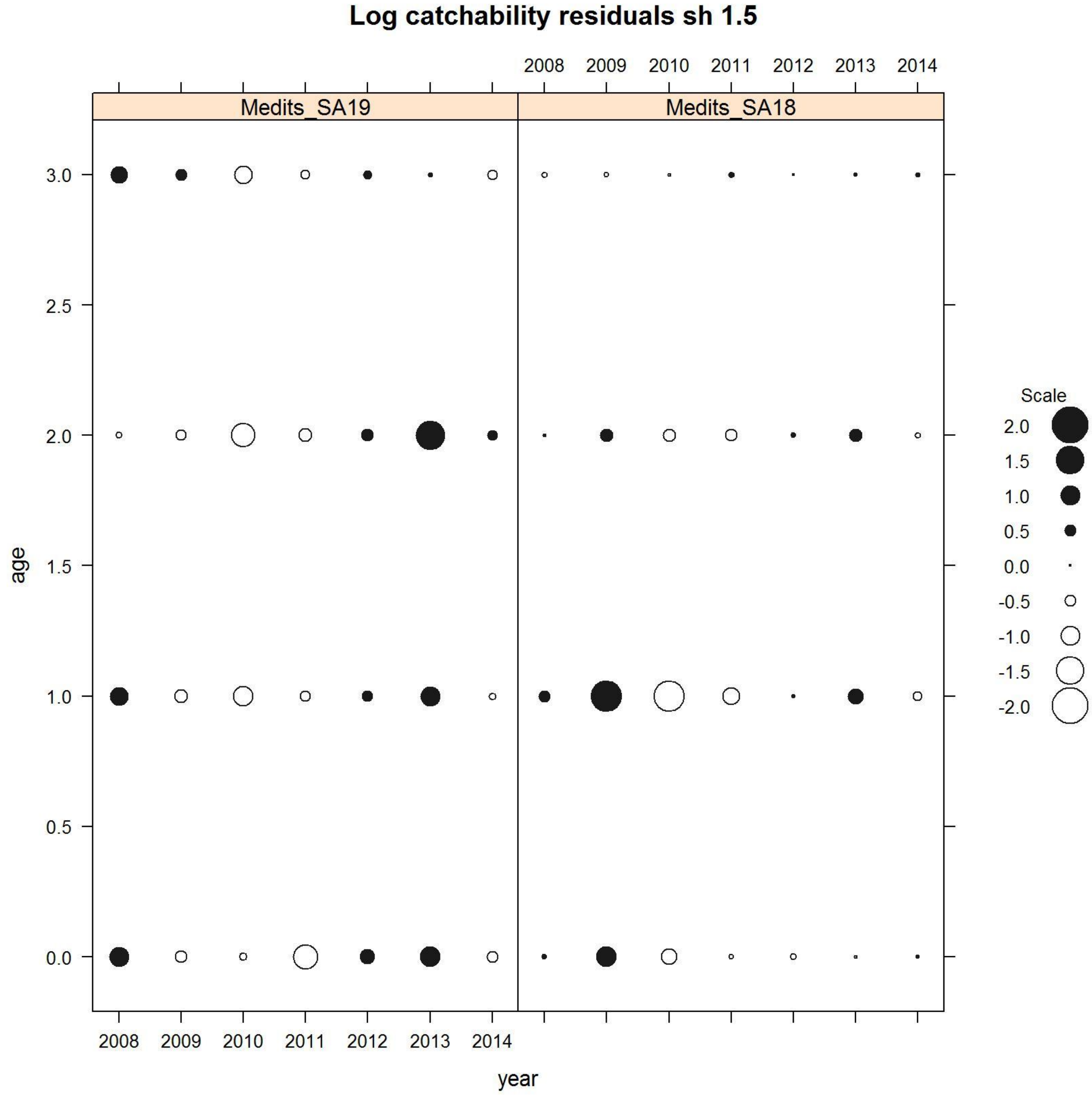


Figure 5.2.15.7.3.2. Giant red shrimp in GSA 18-19. XSA residuals for the MEDITS survey from 2008 to 2014.

The results of the retrospective analysis are shown in Figure 5.2.15.7.3.3.

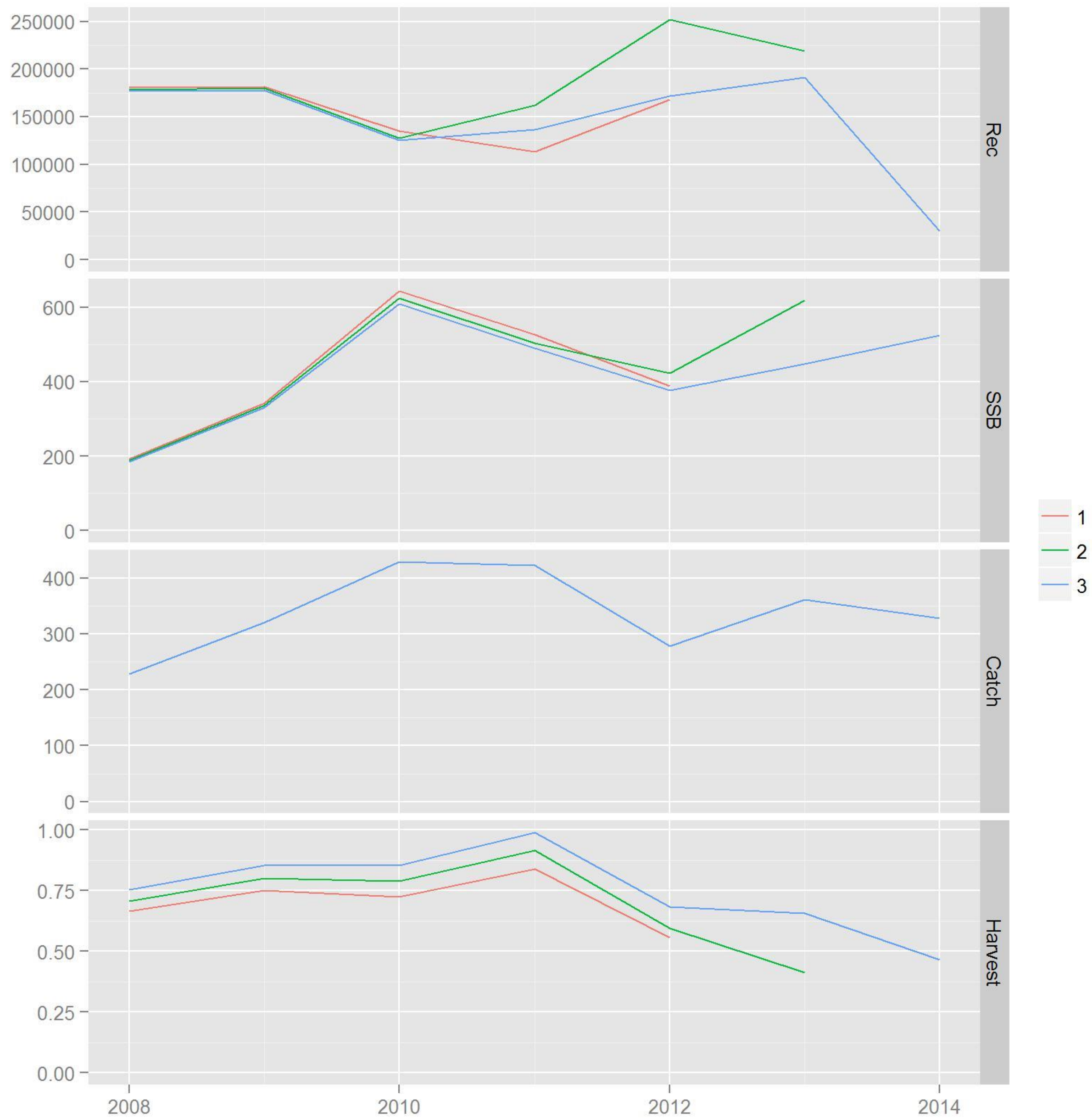


Figure 5.2.15.7.3.3. Giant red shrimp in GSA 18-19. XSA retrospective analysis.

The results of the XSA are shown in the following figure.

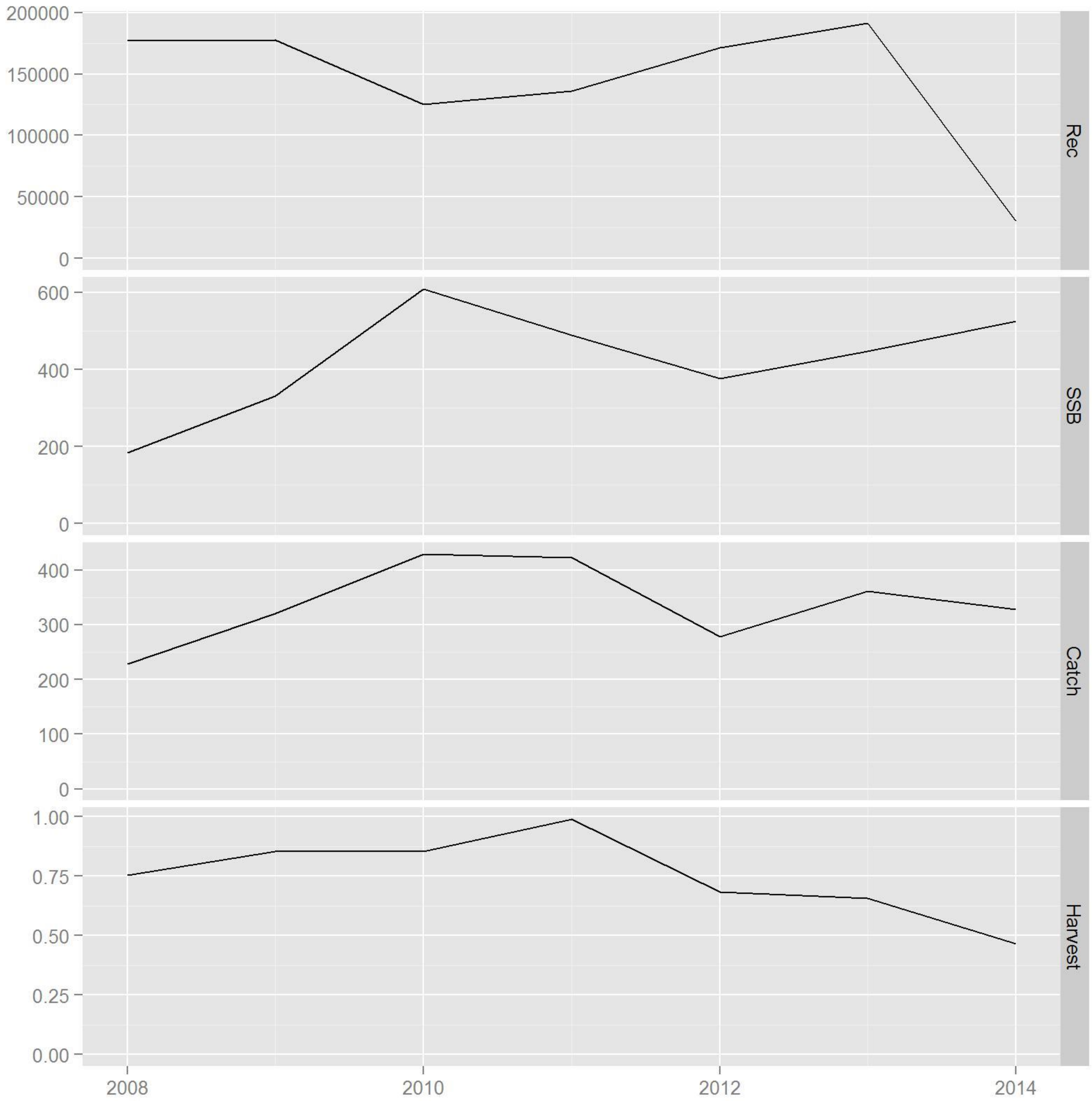


Figure 5.2.15.7.3.4. Giant red shrimp in GSA 18-19. XSA summary results. SSB and catch are in tonnes, recruitment in 1000s individuals.

In the tables 5.2.15.7.3.2 and 3, population estimates of giant red shrimp obtained by XSA are provided.

Table 5.2.15.7.3.2. Giant red shrimp in GSA 18-19. Stock numbers at age (thousands) as estimated by XSA.

Age	2008	2009	2010	2011	2012	2013	2014
0	176935	177922	125354	136235	171601	191140	30222
1	38565	44164	47308	35286	40013	49555	56285
2	2802	9535	12262	16025	8743	13341	14907
3	543	654	1446	2105	1463	1194	1696
4+	226	69	1130	553	312	254	592

Table 5.2.15.7.3.3. Giant red shrimp in GSA 18-19. XSA summary results.

	Fbar (0-3)	Recruitment (thousands)	SSB (t)	Total Biomass (t)
2008	0.753	176935	184	1221
2009	0.853	177922	330	1601
2010	0.853	125354	610	1836
2011	0.987	136235	490	1777
2012	0.681	171601	377	1677
2013	0.655	191140	448	2321
2014	0.463	30222	525	1236

	F at age				
	0	**1**	**2**	**3**	**4+**
2008	0.196	0.776	1.019	1.020	1.020
2009	0.121	0.655	1.450	1.187	1.187
2010	0.071	0.457	1.326	1.556	1.556
2011	0.021	0.767	1.955	1.207	1.207
2012	0.036	0.469	1.551	0.670	0.670
2013	0.016	0.572	1.623	0.408	0.408
2014	0.115	0.394	1.073	0.271	0.271

The XSA results summarized in Table 5.2.15.7.3.3 and in Figure 5.2.15.7.3.4 show a drop in the recruitment in the 2014 and a decreasing trend in the harvest in the last years with an estimated F_{curr} of 0.463.

Method: a4a

Since the time series was very short, only a basic model was fitted to the data until reaching results that were both statistically sound and biologically interpretable. The model run is presented here, and the general specifications of the model in R were the following:

```
qmod1 <- list(~ factor(age),~ factor(age) )
fmod2 <- ~ factor(age) + s(year, k=3)
srmod2 <- ~ s(year, k=3)
fit2 <- a4aSCA(stock=spe.stk, indices=spe.idx, fmodel=fmod2, qmodel=qmod1, srmodel=srmod2)
```

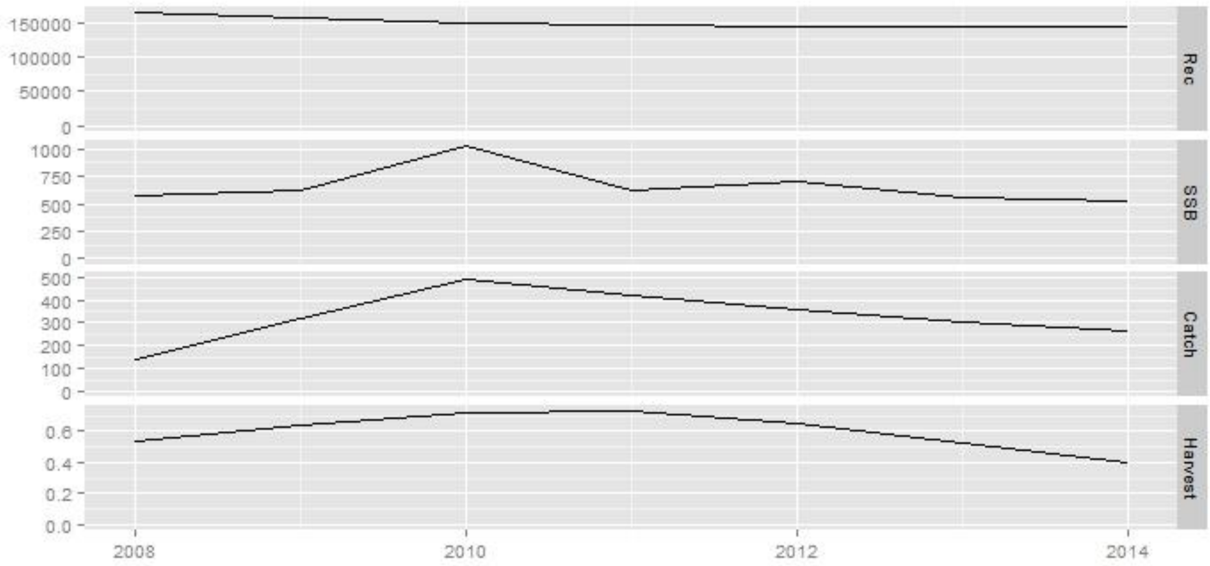


Figure 5.2.15.7.3.5. Giant red shrimp in GSA 18-19. A4A summary results. SSB and catch are in tonnes, recruitment in 1000s individuals.

The diagnostics and the outputs of the a4a model for giant red shrimp in GSA 18-19 are shown in Figure 5.2.15.7.3.6-5.2.15.7.3.10

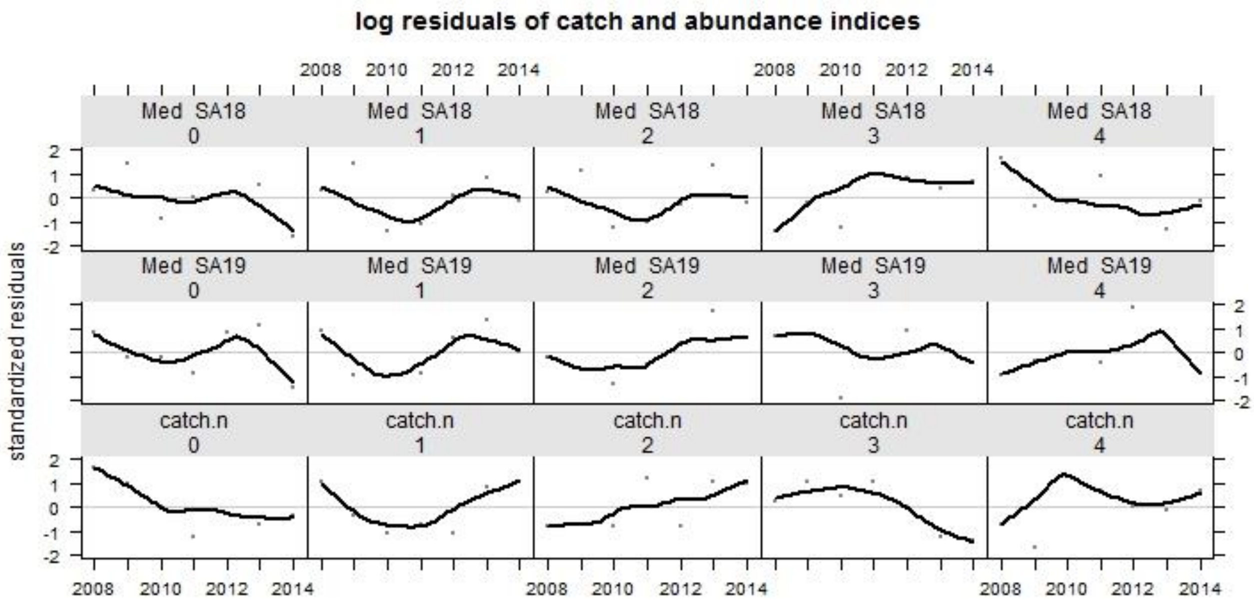


Figure 5.2.15.7.3.6. Giant red shrimp in GSAs 18-19. Log residuals for catch- and MEDITS indices- at-age from the a4a basic model.

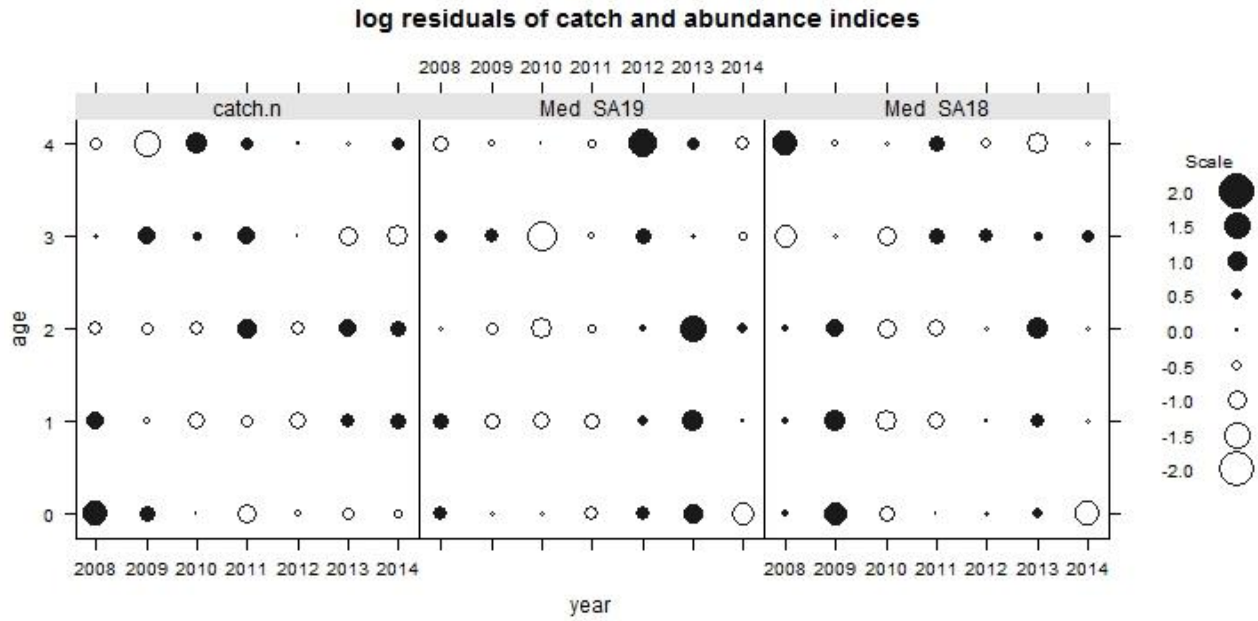


Figure 5.2.15.7.3.7. Giant red shrimp in GSAs 18-19. Bubble plot of log residuals for catch- and MEDITS indices-at-age from the a4a basic model.

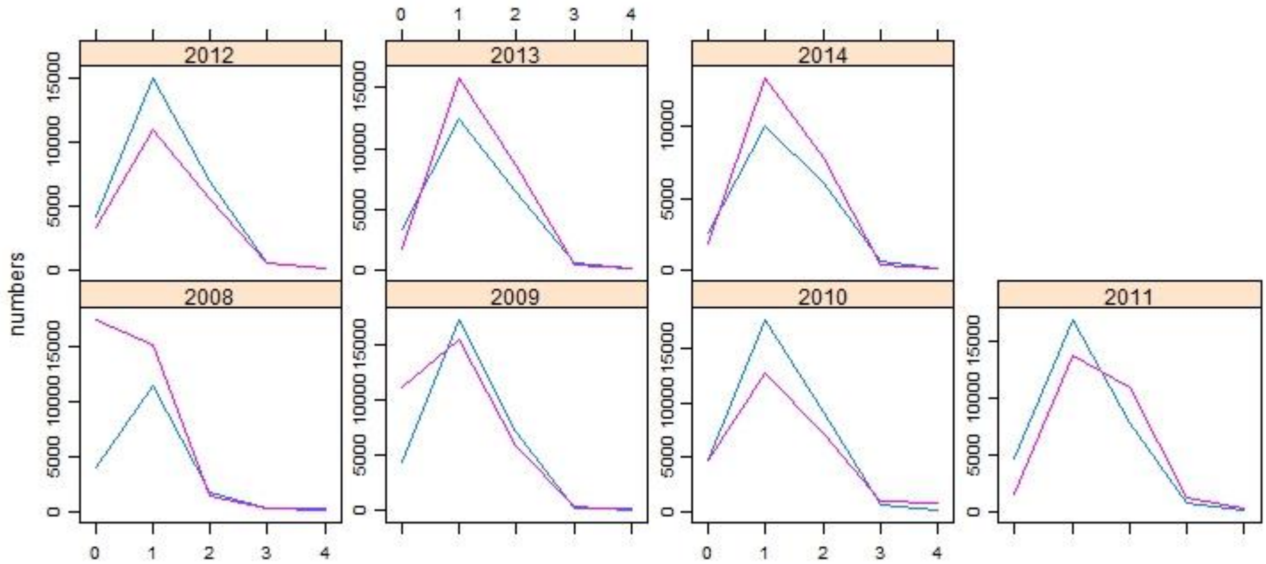


Figure 5.2.15.7.3.8. Giant red shrimp in GSAs 18-19. Observed *vs* fitted MEDITS indices-at-age.

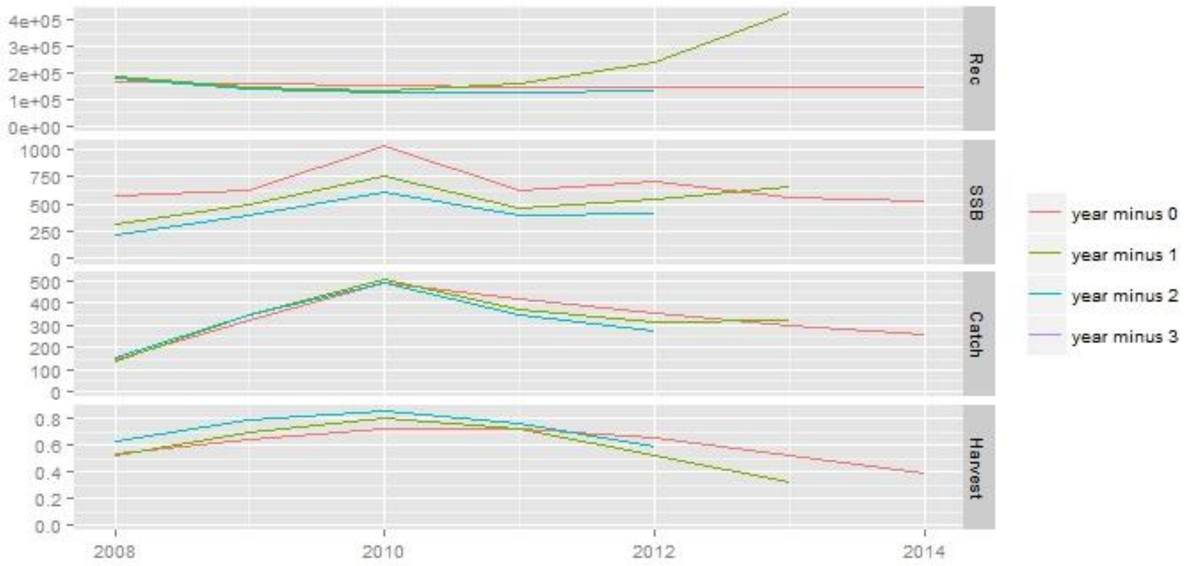


Figure 5.2.15.7.3.9. Giant red shrimp in GSAs 18-19. Retrospective analysis with a4a basic model.

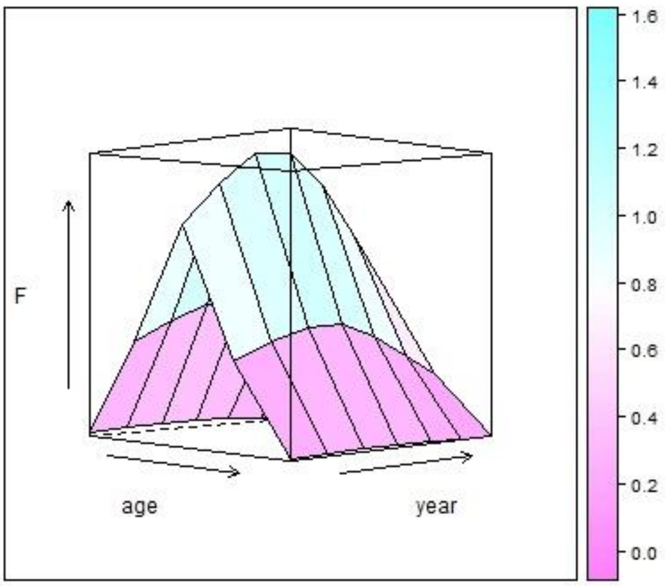


Figure 5.2.15.7.3.10. Giant red shrimp in GSAs 18-19. F-at-age estimated by the a4a basic model.

In the tables 5.2.15.7.3.3 and 4, population estimates of giant red shrimp obtained by A4A are provided.

Table 5.2.15.7.3.3. Giant red shrimp in GSA 18-19. Stock numbers at age (thousands) as estimated by A4A.

Age	2008	2009	2010	2011	2012	2013	2014
0	164795	156424	149628	145129	143066	143006	144052
1	36417	48008	44669	42729	41103	40674	41086
2	3192	11561	13683	11759	11114	11527	12945
3	858	683	1989	1989	1673	1855	2511

4+	14252	10864	8235	6748	5663	4803	4353

Table 5.2.15.7.3.4. Giant red shrimp in GSA 18-19. A4A summary results.

	Fbar (0-3)	Recruitment (thousands)	SSB (t)	Total Biomass (t)
2008	0.531	164795	576	1544
2009	0.635	156424	630	1806
2010	0.716	149628	1034	2403
2011	0.725	145129	616	2032
2012	0.648	143066	712	1866
2013	0.520	143006	559	1993
2014	0.393	144052	529	1902

	F at age				
	0	**1**	**2**	**3**	**4+**
2008	0.042	0.526	1.106	0.448	0.021
2009	0.050	0.629	1.324	0.536	0.025
2010	0.056	0.709	1.492	0.605	0.029
2011	0.057	0.719	1.511	0.612	0.029
2012	0.051	0.642	1.351	0.547	0.026
2013	0.041	0.515	1.084	0.439	0.021
2014	0.031	0.390	0.820	0.332	0.016

Comparison with XSA

The comparison of the a4a results with those from the XSA run displayed a good consistency as the trends for the various variables were found to be the same. Because of the still short time series of data used in the assessment (and the associated limited number of degrees of freedom) it was not possible to use complex smoother functions to model catchability and F-at-age in the a4a framework in order to improve the residuals and so it was decided to base the assessment on the XSA results.

Reference points

5.2.15.1.11 Methods

The FLBRP package allowed a Yield per recruit analysis and an estimate of some F-based Reference Points as F_{max} and $F_{0.1}$. Yield per Recruit computation was made using R project software and the FLR libraries. The fishing mortality rate corresponding to $F_{0.1}$ in the yield per recruit curve is considered here as a proxy of F_{MSY}.

5.2.15.1.12 Input data

The input parameters were the same used for the XSA stock assessment and its results.

5.2.15.1.13 Results

Table 5.2.15.8.3.1. Giant red shrimp in GSA 18-19. Reference points estimated using the Yield per recruit analysis.

refpt	harvest	yield	rec	ssb	biomass
$F_{0.1}$	0.421	292	127001	590	1762

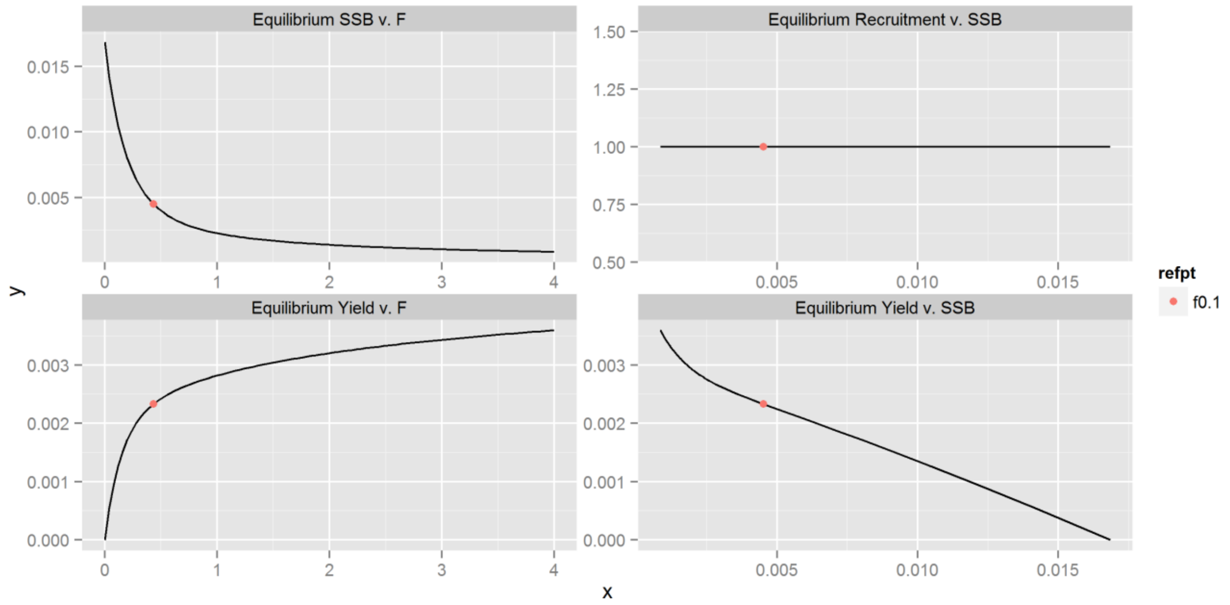


Figure 5.2.15.8.3.1. Giant red shrimp in GSA 18-19. Yield per recruit curve.

Data quality

Giant red shrimp data quality are described in sections 5.2.13.9-5.2.14.9 of this report.

Short term predictions 2015-2017

5.2.15.1.14 Method

A deterministic short term prediction for the period 2015 to 2017 was performed using the FLR routines provided by JRC and based on the results of the XSA stock assessments performed during EWG 15-16.

5.2.15.1.15 Input parameters

The input parameters were the same used for the XSA stock assessment and its results. An average of the last three years has been used for weight at age, maturity at age and F at age.
Recruitment (age 0) has been estimated from the population results as the geometric mean of the last 3 years (99708 thousand individuals).

5.2.15.1.16 Results

Table 5.2.15.10.3.1. Giant red shrimp in GSA 18-19. Short term forecast in different F scenarios. Basis: F(2015) = mean (F_{bar} 0-3 2012-2014)= 0.59; R(2015) = geometric mean of the recruitment of the last 3 years; R = 99708 thousands; SSB(2014) =525 t, Catch (2014)= 328 t.

Rationale	Ffactor	Fbar	Catch 2015	Catch 2016	Catch 2017	SSB 2016	SSB 2017	Change SSB 2016-2017(%)	Change Catch 2014-2016(%)
Zero catch	0.00	0.00	298.07	0.00	0.00	316.37	547.48	73.05	-100.00
High long term yield (F0.1)	0.71	0.42	298.07	152.84	215.60	316.37	411.18	29.97	-53.42
Status quo	1.00	0.59	298.07	201.16	255.17	316.37	370.45	17.09	-38.69
Different Scenarios	0.10	0.06	298.07	25.01	46.44	316.37	524.46	65.77	-92.38
	0.20	0.12	298.07	48.71	86.05	316.37	502.90	58.96	-85.16
	0.30	0.18	298.07	71.19	119.89	316.37	482.67	52.56	-78.30
	0.40	0.24	298.07	92.54	148.87	316.37	463.67	46.56	-71.80
	0.50	0.30	298.07	112.85	173.73	316.37	445.79	40.91	-65.61
	0.60	0.35	298.07	132.19	195.11	316.37	428.95	35.58	-59.71
	0.70	0.41	298.07	150.64	213.53	316.37	413.06	30.56	-54.09
	0.80	0.47	298.07	168.24	229.44	316.37	398.06	25.82	-48.72
	0.90	0.53	298.07	185.07	243.21	316.37	383.88	21.34	-43.60
	1.10	0.65	298.07	216.57	265.57	316.37	357.73	13.07	-34.00
	1.20	0.71	298.07	231.33	274.64	316.37	345.67	9.26	-29.50
	1.30	0.77	298.07	245.49	282.58	316.37	334.22	5.64	-25.18
	1.40	0.83	298.07	259.08	289.54	316.37	323.35	2.21	-21.04
	1.50	0.89	298.07	272.13	295.66	316.37	313.02	-1.06	-17.06
	1.60	0.95	298.07	284.68	301.05	316.37	303.18	-4.17	-13.24
	1.70	1.01	298.07	296.75	305.82	316.37	293.83	-7.13	-9.56
	1.80	1.06	298.07	308.37	310.05	316.37	284.91	-9.94	-6.02
	1.90	1.12	298.07	319.57	313.81	316.37	276.41	-12.63	-2.61
	2.00	1.18	298.07	330.35	317.17	316.37	268.31	-15.19	0.68

Medium term predictions

Medium term forecasts were not conducted because no meaningful stock-recruitment relationship was estimated.

Stock advice

The current F (0.46) is larger than $F_{0.1}$ (0.42), chosen as proxy of F_{MSY} and as the exploitation reference point consistent with high long term yields, which indicates that giant red shrimp in GSA 18-19 is being fished above F_{MSY}. Catches of Giant red shrimp in 2016 consistent with F_{MSY} should not exceed 153 tonnes.

Management strategy evaluation

A Management Strategy Evaluation was run to evaluate if the MSY ranges were precautionary. The F_{MSY} ranges were derived using the formula provided by STECF EWG 15-09. F ranges results were F_{upper}=0.57 and F_{lower}=0.28. B_{lim} was estimated as B_{loss}=184 (t). The following figure shows the results of the MSE.

Figure 5.2.15.13.1. Giant red shrimp in GSA 18-19. Management Strategy Evaluation.

The probability of SSB to fall below B_{lim} at F = F_{upper} is equal to 0.

6 REVIEW THE ASSESSMENTS OF SARDINE AND ANCHOVY IN THE ADRIATIC SEA (GSAs 17-18), MADE BY THE GFCM-SAC AT THE WORKING GROUP ON STOCK ASSESSMENT ON SMALL PELAGIC SPECIES (23-27 NOVEMBER 2015).

Background

At the STECF EWG 15-11 working group in September 2015 a description of all data deficiencies regarding sardine and anchovy in GSAs 17 and 18 were prepared. In addition, the updated assessments for both stocks were carried out, where the FLSAM model settings were revised in order to better reflect the ecology of the species. A number of alternative assessments were tested during EWG-15-11, particularly alternative fits using a4a (Jardim et al., 2015). Furthermore, Eqsim (ICES 2015) was used to estimate F_{MSY} reference points on the basis of a Hockey-stick recruitment model with a fixed breakpoint for both stocks. Finally, two management strategies were evaluated by EWG 15-11: a harvest control rule and a fixed escapement strategy.

A revision of all available catch and survey data for both stocks as well as age reading for sardine and different application of ALK for both species, shift to calendar year for anchovy, has been performed in 2015 by the relevant countries within the framework of the FAO AdriaMed project with the goal to further improve the stock assessments of both stocks. However, no official documentation describing the process was publicly available at the time of STECF EWG 15-16. Finally, in November 2015, stock assessments for anchovy and sardine with the revised data have been carried out by the GFCM Working Group on Stock Assessment (WGSA) of Small Pelagic Species.

ToR 10

DG Mare has requested the STECF EWG 15-16 to review the assessments of sardine and anchovy in the Adriatic Sea (GSAs 17-18), made by the GFCM-SAC at the Working Group on stock assessment on small pelagic species (23-27 November 2015).
In preparation of the STECF EWG 15 16 meeting on Mediterranean assessments, a request for data had been sent to the relevant GFCM and FAO AdriaMed authorities by the JRC secretariat before the start of the meeting.

In detail, AdriaMed was requested to provide the following for both sardine and anchovy in GSA 17-18:
1) documentation supporting the age length keys revision,
2) the new age length keys,
3) revised catch and survey data <u>at age</u>, as used in the GFCM assessment and
4) catch and survey data <u>at length,</u> as used in the GFCM assessment.

GFCM was requested to provide the following for the same stocks:
1) draft report of the benchmark assessments and
2) code to re-run the assessments, if necessary.

FAO AdriaMed has not been able to provide the requested data, indicating that the data belongs to the relevant countries and not to FAO AdriaMed, but also did not provide any of the documentations supporting the revision of the input data. GFCM replied that the draft Report and hence the stock assessment and all connected data has not been finalized and thus GFCM cannot make them available to STECF EWG 15 16. GFCM Secretariat stated that the files including the input data used for

the assessments are protected by the rules of confidentiality of the GFCM, as explained in the disclaimer included in the Working Groups internal webpage, and cannot be disclosed even after SAC. Additional effort was made by the STECF Secretariat to gain access to the data, revised in AdriaMed, by sending requests directly to the countries involved (Italy, Croatia and Slovenia). A positive reply was sent only by the Slovenian authorities. Croatia in order to improve the quality of scientific evaluation carried out by STECF, stated to be ready to submit the time series not covered by DCF, upon official request and data-call by the EU Commission.
Croatia also believe that it is essential that national experts are present while processing this data, given their scientific expertise and data knowledge for the Adriatic basin, to ensure that data is interpreted adequately.
Italy replied stating that the official data for these stocks are those sent through the DG MARE DCF data call. Thus, it was not possible to access the data revised in AdriaMed and in the GFCM small pelagics working group through Member States. At the time of EWG 15-16 there are two official datasets for sardine and anchovy in GSA 17, one reflected by the DCF data and one revised in AdriaMed and in the GFCM small pelagics working group.
Since the input data and the assessment report of sardine and anchovy in the Adriatic Sea prepared by the GFCM-SAC Working Group on stock assessment on small pelagic species was not made available to STECF EWG 15-16, STECF EWG 15-16 was not able to perform the revision requested under the TOR 10 nor to conduct an assessment of sardine and anchovy in GSA 17-18.
There are different levels of review of a stock assessment that require different data, ranging from no data to complete raw data. In relation to the specific review to be performed, the following data is required:

1. To perform the assessment **document review**, the original assessment document should be provided, but not the input data.
2. To perform the assessment **fitting review**, the catch-at-age data and catch-at-length, survey matrices, age-length keys, all other assessment input data (maturity, natural mortality, weights,...) and scripts used to run the GFCM assessment should be provided. From this data alternative assessments could be trialled allowing for the diagnostics and implications to be investigated. Such a revision assumes that the inputted data are correctly pre-processed, but retains the capability of applying a growth model to the length data which is the key issue given the future revision of ALK for anchovy.
3. To perform assessment **data/pre-processing review**, the "raw data" including haul-level survey data covering the entire time series, survey schema/description, catch-at-length by fleet, age-length keys and all other data pre-processed to produce the data for the point 2 above should be provided. From this information, most analysis are possible, with a comment, that processing data at this level requires considerable expert knowledge of how the data were collected and would require extensive work.

Points 1-3 describe a classification of review levels and consequent data requirements that EWG 15-16 consider necessary as a general framework for stock assessment reviews

Following up from the September meeting hosted by DG MARE, the need for a consensus and alignment of the stock assessments of sardine and anchovy performed separately by GFCM and STECF in the Adriatic Sea emerged. The request to STECF, made by MARE, to review the latest GFCM assessment was in line with the point 2 above and it is clear that the more in depth review of an

assessment will likely generate better quality and reliability of the final results. EWG 15-16 considers that to allow a review of any assessment the level and the conditions for a stock assessment review should be clearly specified.
Given that the input data for both stocks of anchovy and sardine were substantially revised in different key aspects as described above, EWG 15-16 considers that to perform a review of the assessments, a platform should be established where the same data are available across working groups (STECF, GFCM, AdriaMed). EWG 15-16 consider that the minimum level at which the review should be performed should be in line with the point 2 with associated data requirements.

EWG 15-16 hopes that due steps are taken across institutions involved to ensure that in the future the conditions will be met for the STECF EWG to review stock assessments made by GFCM and vice versa.

7 REVIEW THE SCIENTIFIC BASIS OF THE SPANISH MANAGEMENT PLAN "RASTRILLO DE CADENAS" AND ITS SAMPLING PROGRAMME. MAKE ANY APPROPRIATE COMMENTS AND RECOMMENDATIONS, WITH RESPECT TO THE MEASURES PROPOSED THEREIN. PARTICULARY, ADVICE WHEATHER THE MANAGEMENT PLAN ADDRESSES THE ELEMENTS LISTED IN ANNEX III.

ToR 11. Review the scientific basis of the Spanish management plan rastrillo de cadenas and its sampling programme. Make any appropriate comments and recommendations, with respect to the measures proposed therein. Particularly, advice whether the management plan addresses the elements listed in Annex III.

ANNEX III

The STECF is request to advice whether the management plan addresses: (a) the description and classification of the fishing gear rastrillo de cadenas; (b) the characterisation of the fishery, including the fishing grounds, target and non-target species, fleet composition, fishing effort, total catches (landings and discards) and CPUE; (c) size structure of the target and accompanying species (both landings and discards); (d) conservation objectives and; (e) technical and conservation measures that are consistent with the precautionary approach to fisheries management.

Particularly, advice whether the scientific monitoring plan (Appendix III) foresees the collection of the relevant information to estimate: (i) the status of the exploited resources, including quantifiable targets; (ii) the conservation reference points; (iii) the level of unwanted catches that are below the MCRS2; (iv) the socio-economic performance of the fishery; and (v) the impacts of the fishing activity on the marine ecosystem and estimation of survival rate of discarded individuals. Since the information to be collected is intended to complement the current management plan, the STECF should have a special focus on this point.

EWG 15-16 comments

The submitted management plan (MP) of rastrillo de cadenas includes information on the shellfish dredge fishery, characteristics of the fishing gear, legislation in force (chapters 1 to 5); a dredge fishing management plan proposal (chapter 6) and three annexes (Annex I- Technical and scientific assessment; Annex II- Scientific study for the development of a management plan for the type of dredge boat used in Catalonia; and Annex III- Technical and scientific monitoring during the development of the management plan).

The MP regards the utilization of a gear, rastrillo de cadenas, which can be classified as a dredge towed by a vessel. One or two devices can be towed by a vessel. In the case of a single towed gear, or two mounted in a line, the maximum width at the mouth will be 2.5 m, and 2.0 m in the case two devices are set in parallel. The opening of the mouth during trawling is kept unchanged by the positioning of a metallic structure across its mouth. The gear is towed at relatively fast speed, 5-7 knots, similar to that of the beam trawl used in the Adriatic (“rapido”, 7 knots). Although no minimum mesh size is compulsory for such gears, in the MP a minimum mesh size of 40 mm is proposed.

2 Minimum Conservation Reference Size (MCRS)

The target species of the gear are the gastropod mollusc purple dye murex (*Bolinus brandaris*) and the bivalve mollusc striped venus (*Chamelea gallina*). Other species of commercial interest (cephalopods, other bivalves and decapod crustaceans) are part of the bycatch. Finfish constitute almost always a small proportion of the catches.

The rastrillo de cadenas is used mainly in the Ebro River Delta (southern Catalan coast) and in also the central part of the Catalan coast. The fishing grounds of the two target species are located at different depths depending on the abundance of the main target species, shallower those of striped venus (3- 10 m depth) than those of purple dye murex (12-30 m depth).

According to Regulation (EC) No.1967/2006, "dredge" means gears conceived to catch bivalves, gastropods or sponges (Art.2). Fishing activities within the 3 miles distance from the coast with such gear operating on the bottom is allowed, irrespective of the depth, provided that the catch of species other than shellfish does not exceed 10% of the total live weight of the catch (Art. 13). In the MP it is stated that "shellfish" refers to "marine organisms other that finfish" based on the interpretative document forwarded by the EC in August 2014. This interpretation enlarges the range of organisms that can be included in such category. Thus, the definition of "shellfish", that is, the species that would be included under "shellfish", is basic for the rastrillo de cadenas to be classified as dredge or as beam trawl.

The MP takes into account the requirements of Article 19 of Regulation (EC) No.1967/2006 for fishing activities in the Mediterranean and includes proposals of technical management measures considered useful for ensuring the sustainable exploitation of shellfish resources targeted by dredgers in Catalonia using the rastrillo de cadenas. However, information regarding the fishery e.g. fleet structure, exerted effort, specific composition of catches and discards, fishing grounds, landings and CPUE trends of the two target species (*Bolinus brandaris* and *Chamelea gallina*), catch size distributions of both target and bycatch species, is scarce or non-existent, and in most of the cases not updated. Moreover, no information on the status of the involved stocks is given, neither any conservation objective or management measures necessary to grant a sustainable use of the exploited resources with this gear. There is a complete lack of information on the impact of the use of the gear on the fishing grounds and benthic community along the swept area. Such kind of data should include the likely hidden mortality produced also on target stocks due to the mechanic action of chains and gear mouth. Other information that should be included in the plan regards the survival rates of the fraction of the catch that is retained and successively discarded to the sea.

The maximum number of special permits for vessels to use rastrillo de cadenas would be 34 as indicated in the "Regulatory body of the MP". Nevertheless, elsewhere in the text it is indicated the current number of authorized vessels as 37 (p.12) and also, 30 (p.69).

The EWG notes that even though maps of fishing grounds are supplied, they are not accurate as they do not reflect the differences in distribution of the fleets when targeting one or the other main resources. As for the spatial distribution of the fishing effort, maps should be provided separately for Bolinus brandaris and Chamelea gallina for the southern and central areas of the Catalan coast where the fleet operates. Maps should include bathymetry and type of bottom. This information is basic also for the assessment of the impact of the gear on the benthic communities.

In Annex II, with the aim of defining the catch composition of the rastrillo de cadenas, 2011-2014 merged data were used. Tables of results are not reported and these are only represented in figures expressed as percentages for species groups. Data are combined in different ways, showing the different contribution of the species groups to catches depending on the fishing gears considered. As a single vessel may utilize different gears, the data show catch compositions of gears combinations as “rastrillo con cadenas”(RC); RC+net; and catches not using RC. This method for representing results is rather confusing.

The feassibility of authorization of simultaneous use of different fishing devices proposed in the “Regulatory body” needs further clarification. In page 34, paragraph 7), it is stated that “this Order considers that other fishing or shellfishing activities using net fishing gear or hook cannot be conducted simultaneously during the same day”, while in page 37, Art.9 it is indicated that “the same day, it is not possible to combine the use of dredger boat with any other fishing method, appliance or utensil for fishing or shellfishing”. It remains unclear whether traps and buckets targeting cephalopods and bivalves will be allowed to be used simultaneously with the “rastrillo con cadenas”, as it is the case at present with the current regulations in force.

Item 7.2 in page 37 should be checked, since it is stated that “The catches of different species of molluscs, crustaceans and echinoderms may not exceed 10% of the total catch by weight at the time of landing”.

Regarding the monitoring committee of the MP (page 38) it seems advisable that the institution responsible for the scientific monitoring be part of that committee.

The socio-economic performance of the rastrillo de cadenas fleet is not considered in the MP.

The EWG notes that in the MP it is stressed that during the first year of implementation a scientific monitoring will be undertaken. The monitoring programme, aimed at determining, accurately and conclusively, the catch composition the rastrillo de cadenas as well as that of other authorized gears used by the same vessels, is specified in Annex III. The MP proposes a revision at the end of the first year of implementation based on the results of this study. In the event that the scientific monitoring will show that the catch composition of rastrillo de cadenas does not fit with the necessary conditions for applying to this fishery the specific regulations of a dredge, the MP will be modified. The EWG considers that while such eventual modifications are not specified, it is in any case difficult to conceive changes in the management measures that are consistent with the current legal frame.

Current catches of *Bolinus brandaris* are much lower than those more than two decades ago. Current annual landings of purple dye murex are 135.8 tonnes in the whole 2011-2014 period (MP page 41) and the fleet is made up of 34 vessels, while in 1993 were 360 tonnes and the fleet consisted of 60 vessels (Martín et al. 1995). The longest time series of landings and CPUE data of Bolinus brandaris and Chamelea gallina available in the area should be used, at monthly and annual scale, to show the landings and CPUE trends and the seasonality of the landings. These data should be presented also in tables. The monthly data would allow assessing the alternation in the targeted species along the year. This information, combined with that of the size structure of the target species during the year, may be useful for the definition of temporal closures. CPUE trends of the target species might allow knowing changes in biomass along the analyzed period. The information of the period 2011-2014, the only period considered in Annex II, is not sufficient for identifying trends in the target species biomass.

EWG 15-16 conclusions

The EWG concludes that the information included in the MP is not sufficient for assessing the sustainability of the activity neither under biological nor socio-economic points of view.

Regarding the questions included in ToR 11:

(a) the description and classification of the fishing gear rastrillo de cadenas
The characteristics of the gear are well defined. The results on the landings species composition are unclear; hence, it is not possible to know whether the use of this gear can be authorized within the 3 miles distance from the coast.

(b) the characterisation of the fishery, including the fishing grounds, target and non-target species, fleet composition, fishing effort, total catches (landings and discards) and CPUE
The characterization of the fishery is incomplete and mostly not updated. Catch composition (landings and discards) by species is not given. Landings and CPUE trends of the target species are not provided. The spatial information on the areas where the fleet operates (by area and target species) is not well defined.

(c) size structure of the target and accompanying species (both landings and discards)
No information provided, neither for the target species nor for the by-catch.

(d) conservation objectives
The MP aims to the conservation and sustainable exploitation of the resources. Nevertheless, no specific measures are proposed.

(e) technical and conservation measures that are consistent with the precautionary approach to fisheries management.
Some technical measures are proposed (minimum mesh size of 40 mm, temporal closures, minimum depth of 12 m for the fleet operating in the central coast). No further explanation is given on the likely consequences of the enforcement of such measures.

Regarding the specific items in the second paragraph of ToR 11, the information collected during the planned monitoring plan will not be sufficient to fully address all the questions. With the proposed data collection:

(i) the status of the exploited resources, including quantifiable targets
Limited indications can be derived on the status of the exploited stocks. Quantifiable targets cannot be defined with one year data. The analysis of landings and CPUE time series is not foreseen.

(ii) the conservation reference points;
In the absence of any stock assessment, the identification of any conservation reference points is unfeasible.

(iii) the level of unwanted catches that are below the MCRS
Yes, the proposed sampling may allow identifying the species composition of the discarded catch.

(iv) the socio-economic performance of the fishery
This issue is not considered in the monitoring plan.

(v) the impacts of the fishing activity on the marine ecosystem and estimation of survival rate of discarded individuals.
The collected data may allow determining quantitavely the removals of the benthic communities affected by this gear. Survival studies of discarded individuals are not foreseen.

EWG 15-16 recommends the exclusive use of the "rastrillo de cadenas" during the days fishermen intend to utilize it in order guarantee that the recorded daily catches, catch composition, discards, etc., correspond to the gear under study.

8. DATA OVERVIEW

The data call was issued on April 2015. The 'legal' deadline for submissions was the 2nd of July 2015. Upon communication with the member states some data tables were corrected and re-uploaded in relation to the 'operational' deadline of the 17th August 2015.

Data was uploaded by each country according to the following table:

Table 8.1.1. Timeline of data upload from Mediterranean Member States, data call deadline of the 2nd of July 2015.

	CYP	ESP	FRA	GRC	HRV	ITA	MLT	SVN
A_CATCH	02/07/15	01/07/15	02/07/15	**11/08/15**	01/07/15	30/06/15	02/07/15	05/06/15
B_LANDINGS	01/07/15	01/07/15	02/07/15	**02/08/15**	01/07/15	30/06/15	02/07/15	05/06/15
C_DISCARDS	01/07/15	**04/08/15**	02/07/15	**14/08/15**	01/07/15	01/07/15	02/07/15	05/06/15
D_EFFORT	02/07/15	01/07/15	02/07/15	02/07/15	02/07/15	30/06/15	02/07/15	05/06/15
ML	**03/07/15**	01/07/15	02/07/15	**03/07/15**	01/07/15	01/07/15	02/07/15	05/06/15
MA	**03/07/15**	01/07/15	02/07/15	**13/07/15**	01/07/15	01/07/15	02/07/15	05/06/15
GP	02/07/15	01/07/15	02/07/15	**17/08/15**	01/07/15	01/07/15	02/07/15	**No Data Submitted**
SRL	02/07/15	01/07/15	02/07/15	**03/07/15**	01/07/15	01/07/15	02/07/15	05/06/15
SRA	02/07/15	01/07/15	02/07/15	**13/07/15**	01/07/15	01/07/15	02/07/15	05/06/15
MEDITS_TA	**No Data Submitted**	01/07/15	19/06/15	02/07/15	**31/07/15**	30/06/15	02/07/15	05/06/15
MEDITS_TB	**No Data Submitted**	01/07/15	19/06/15	**11/07/15**	**31/07/15**	30/06/15	02/07/15	05/06/15
MEDITS_TC	**No Data Submitted**	01/07/15	19/06/15	**11/07/15**	**31/07/15**	30/06/15	02/07/15	05/06/15
MEDITS_TE	**No Data Submitted**	01/07/15	19/06/15		**31/07/15**	30/06/15	02/07/15	05/06/15
ABUND	**No Data Submitted**	01/07/15	19/06/15	**14/08/15**	02/07/15	30/06/15	02/07/15	**No Data Submitted**
BIOMASS	**No Data Submitted**	01/07/15	19/06/15	**14/08/15**	02/07/15	30/06/15	02/07/15	**No Data Submitted**
ABUND_BIOM	**No Data Submitted**	01/07/15	19/06/15	**15/08/15**	02/07/15	30/06/15	02/07/15	**No Data Submitted**

The overall 2015 Data Call performance of data coverage, timeliness and progress of submissions by member state and main table/variable will be made available by the end of the year and after the completion of the EWG 15-16 Mediterranean stock assessments part 2, on the dedicated weblink: http://datacollection.jrc.ec.europa.eu/coverage

MEDITS Specific data problems

MEDITS Temporal drift

According to the MEDITS manual V 7 2013, the period of the MEDITS survey is centered in June (from May to July). This is a fundamental aspect of a standardized international survey that is used to perform stock assessment and provide management advice. The timing of the survey has a clear effect on the number and the size of fish. Shifts in survey timing destroy the internal consistency of a survey and cohorts are more difficult to track in time. This can result in poorly fitting stock assessments and poor estimates of stock status.

Over the years, 1994-2014, there is a concerning split of the survey timing between countries (Figure 8.1). France and Spain tend to respect the protocol and center MEDITS around the period May-June-July. On the other hand Italy is increasingly postponing the survey to the late summer/fall and in 2014 reached the months of November and December in GSA 17 and 16 respectively.

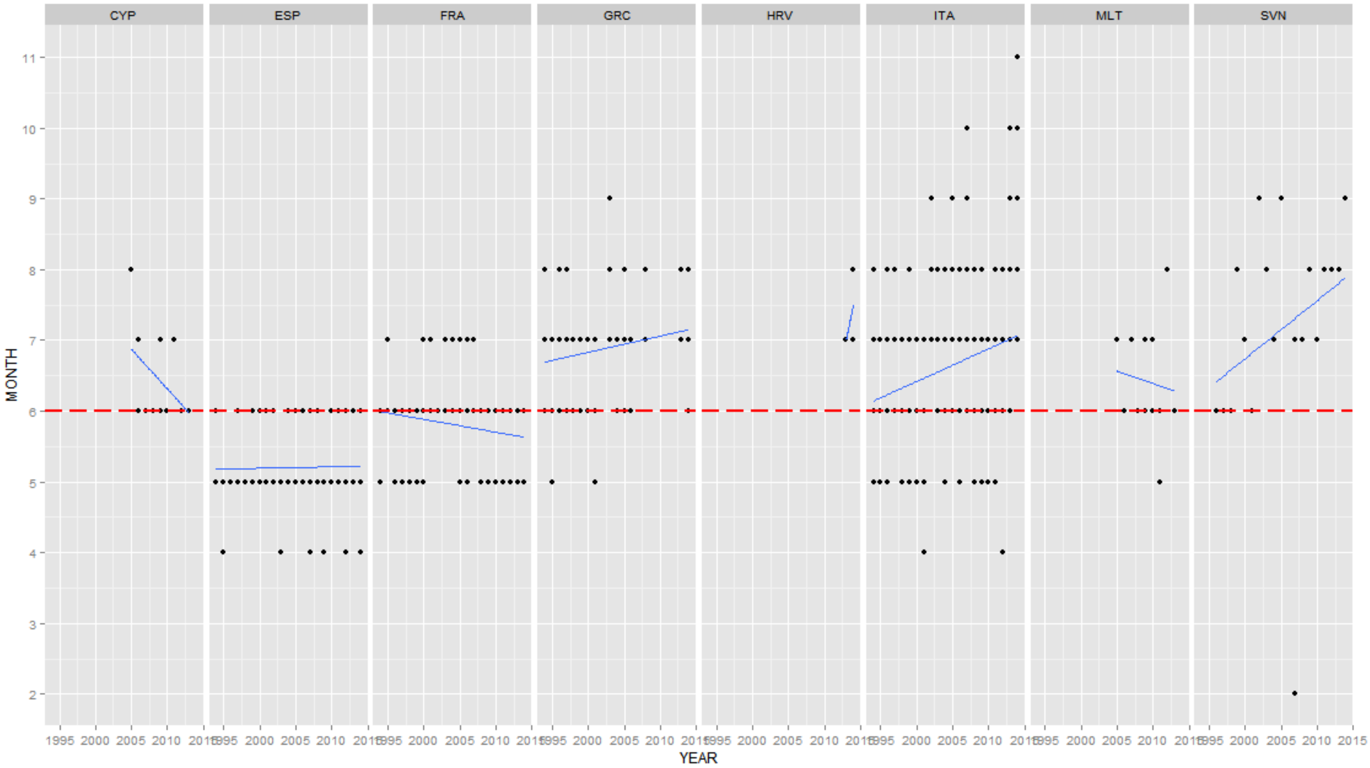


Figure 8.1 Timing of MEDITS trawl survey by Country. Dots represent the months within year when MEDITS was performed, blue line is a fit to indicate the trend between month~year, red line shows the month of June around which the survey should be timed.

In GSA 17 the situation is of serious concern in 2014 since the survey was performed over four consecutive months (August to November). Malta performed the 2014 survey in December. The temporal trend is shown (Figure 8.2). Surveys performed after the month of September should not be considered compliant with the MEDITS protocol.

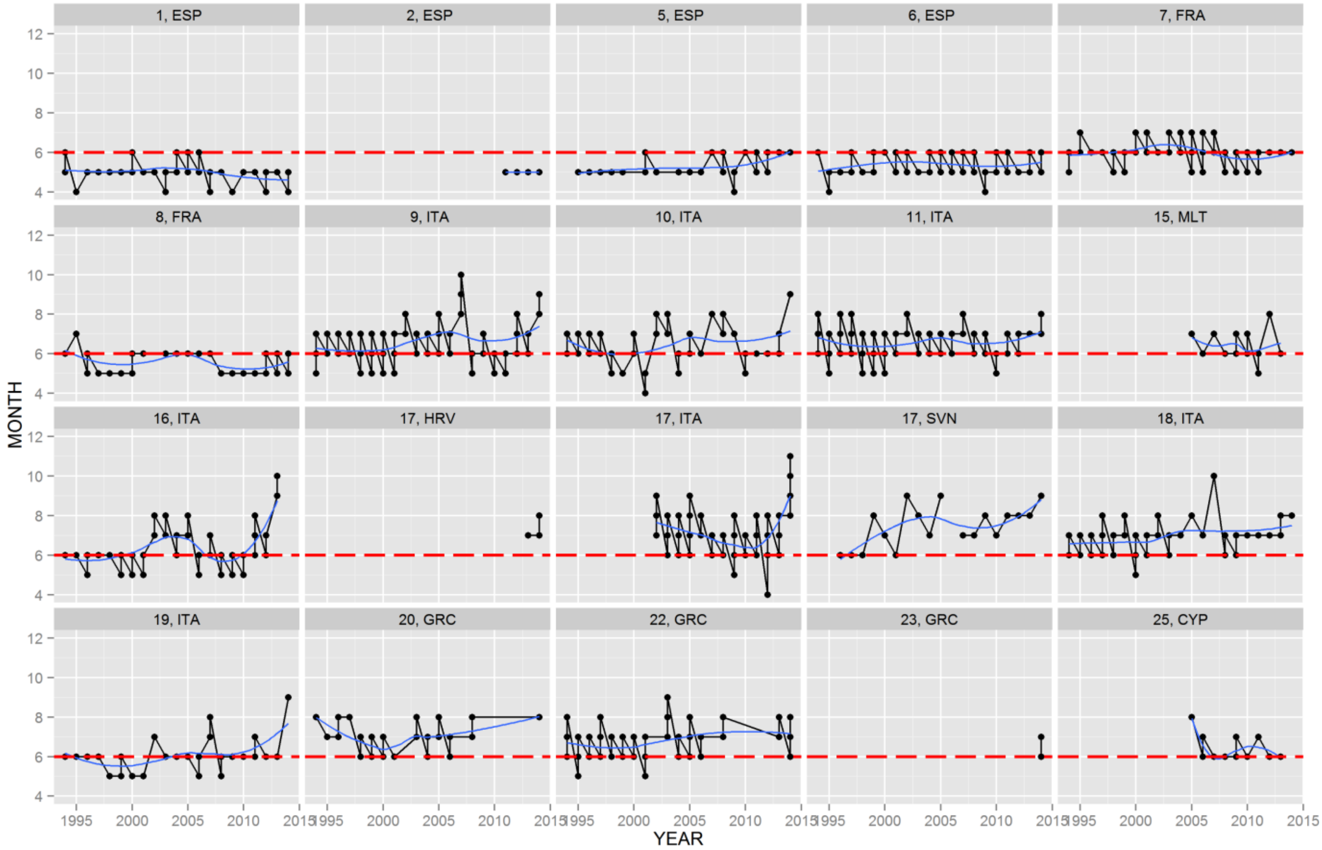


Figure 8.2. Timing of MEDITS trawl survey where each panel is a combination of Country/Area. Dots represent the months within year when MEDITS was performed, blue line is a fit to indicate the trend between month~year, red line shows the month of June around which the survey should be timed.

8.1 Stock Specific Data Issues

Hake in GSA 17-18

The assessement of *Merluccius merluccius* in GSA 17 and 18 was pursued using all the data available. Specifically, for GSA 18 data from the last GFCM stock assessment were used, whereas from GSA 17 data provided by STECF, combined with Croatian data collected in the framework of Adriamed for years from 2008 to 2012, were employed.

EWG 15-16 data needed some reconstructions. In particular, for those years where discard is reported but without length composition, this was reconstructed from the information presented in previous or following years. Moreover, some landings data and size structure of the eastern countries were reconstructed from the information presented in most recent years.

Hake in GSA 19

Data from DCF 2015 were used. A difference in the sum of products compared to landings was always far less than 10%. Discards data of 2006, 2009, 2010, 2011, 2012, 2013 and 2014 were available. Information on number of samples for landings, discards and catches, as well as the number of measurements by length for landings, discards and catches were also available. Number of otoliths was also available. MEDITS raw data used for this assessment have been processed by the

expert using the software FishTrawl. Biological parameters by length and age and sex ratio were available for the whole time series (2002-2014).
In 2014 the survey was shifted in September as a consequence of the administrative process undertaken Italian Ministry of Agriculture.

Red mullet in GSA 17-18
The assessement of *Mullus barbatus* in GSA 17 and 18 was performed using all the data available. Specifically, both for GSA 17 and GSA 18 data from the last GFCM stock assessment were used. Data from Albania e Montenegro were provided by AdriaMed, as well as, Croatian data before the accession to the EU (years from 2008 to 2012). Some data needed some reconstructions. In particular, for those years where discard and the respective length composition or only the length composition are not reported; these were reconstructed from the information presented in previous or following years.

Red mullet in GSA 19
Data from DCF 2015 were used. A difference in the sum of products compared to landings was always far less than 10%. Discards data of 2009 and 2011 to 2014 were available. Information on number of samples for landings, discards and catches, as well as the number of measurements by length for landings, discards and catches were also available. Number of otoliths was also available. MEDITS raw data used for this assessment have been processed by the expert using the software FishTrawl. Growth, maturity by length and age and sex ratio were available for the whole time series (2002-2014).

Common sole in GSA 17
With the exception of what reported in section 5.2.5.6.2, no other major issues have been observed in tha data available form the 2015 official DCF data call.

Norway lobster in GSA 17-18
The main data issues for this stock have been MEDITS in 2014, being carried out over a time span of 4 months, in violation of the MEDITS protocol. Based on official DCF data it is not possible to identify Nephrops from the area of Pomo since the data are collected at whole GSA 17 level. It is thus not possible, with the current data available at EWG 15-16, to detect differences in growth and size from the Pomo area.

Spot-tail manits shrimp in GSA 17
Several issues has been identified in the data for *S. mantis* in GSA17.
First of all, 2007 Italian landings data show a peculiar LFD, which seems to highlight some differences in the measuring methodology compared to the following years: therefore this year was discarded and not included in the assessment. Also, the sudden drop in GNS landings registered in 2013 should be further investigated.
MEDITS data for this species are considered completely unreliable for several reasons: a change in the measuring methodology between 2009 and 2011, the few numbers of specimens measured and the huge temporal extension of the MEDITS survey in 2014 (from May to November).

Spot-tail mantis shrimp in GSA 18
The assessment was based on the EU DCF data (landings and discards) collected by Italy in the western part of GSA 18. Data from Albania and Montenegro were not available during EWG 15-16.

Italian annual landings data were available since 2006 wherease size/age structures of the landings covered the period 2007-2014. Discards data were not available before 2008 and were reconstructd during EWG 15-16 using the mean proportion of discard observed in 2008-2010. The size/age structure of landing and discards was not available for gillnets and trammel nets in the years 2007 and 2008. The age structure of these two years was reconstructed using the reported landings/discards and the average age structure of the catch of the two gear reported for the years 2010-2014. The impact of such reconstructed data on the assessment results can be considered however negligible considering that the contribution of the gillnets and trammel nets catch over the total annual landing was less than 10% in most of the years.

Spot-tail mantis shrimp in GSA 17-18
Spot-tail mantis shrimp data quality are described in sections 5.2.7.9 and 5.2.8.9 of this report.

Deep-water rose shrimp in GSA 18
The assessment was based on the EU DCF data (landings and discards) collected by Italy in the western part of GSA 18. Data from Albania and Montenegro were from FAO Official Statistics (FAO, 2014) and national statistics. Some of the landings data and size structure of the landings were collected and reconstructed under the framework of the Adriamed pilot project.

Deep-water rose shrimp in GSA 19
Assessments were performed using the time series as reported by DCF 2015. No major issues have been observed in tha data available form the 2015 official DCF data call.
A sum of products correction was applied to the landings at age matrix.
Landings in 2007 and 2008 (collection was not mandatory by DCF) were reconstructed using the mean landings/discards proportion in two contiguous years (2009-2010).
Row MEDITS data used for this assessment have been provided by JRC.
In 2014 the MEDITS survey was carried out in September.

Deep-water rose shrimp in GSA 17-18-19
Data from DCF 2014 as submitted through the Official data call in 2015 were used. Discards for GSA 17 were present just for 2011, 2013 and 2014 for the Italian fleet. Some of the discard data were considered unreliable since the length of the discarded animals were above the minimum landing size. Landings data for GSA 17 were incomplete. Italian landings were present just for 2002, 2003, 2006, 2011, 2013 and 2014. Croatian landings were present just for 2014 in the DCF database because previously there was no obligation to monitor that species.
MEDITS data from Croatia in GSA 17 in the database were present just for 2013 and 2014.

Giant red shrimp in GSA 18
Landings data for 2003 appears to be at least partly erroneous since 12.7 tonnes of giant red shrimp caught by set gillnets (GNS) were reported by the Italian authorities.

Except for 2009 and 2011 no data on total discard weights or discards length frequency distributions were reported through the official DCF.

Data on mesh size were available for 2004 to 2008 (40D50) and 2012 to 2014 (50D100); no information on mesh size is available for 2009 to 2011. As a result it is not possible to interpret the available information on discard length frequencies (discard CL range in 2009 is 19-30 mm; in 2011 it is 14-19 mm).

Giant red shrimp in GSA 19
Demographic structures of OTB landing and discard were available for the period 2008-2014.

Giant red shrimp in GSA 18-19
Giant red shrimp data quality are described in sections 5.2.13.9-5.2.14.9 of this report.

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10 CONTACT DETAILS OF STECF MEMBERS AND OTHER PARTICIPANTS

1 - Information on STECF members and invited experts' affiliations is displayed for information only. In any case, Members of the STECF, invited experts, and JRC experts shall act independently. In the context of the STECF work, the committee members and other experts do not represent the institutions/bodies they are affiliated to in their daily jobs. STECF members and experts also declare at each meeting of the STECF and of its Expert Working Groups any specific interest which might be considered prejudicial to their independence in relation to specific items on the agenda. These declarations are displayed on the public meeting's website if experts explicitly authorized the JRC to do so in accordance with EU legislation on the protection of personnel data. For more information: http://stecf.jrc.ec.europa.eu/adm-declarations

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11 List of Background Documents

Background documents are published on the meeting's web site on:
http://stecf.jrc.ec.europa.eu/web/stecf/ewg1516

List of background documents:

1. EWG-15-16 – Doc 1 - Declarations of invited and JRC experts (see also section 10 of this report – List of participants)

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